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TECHNOLOGY REVIEW

January 1950

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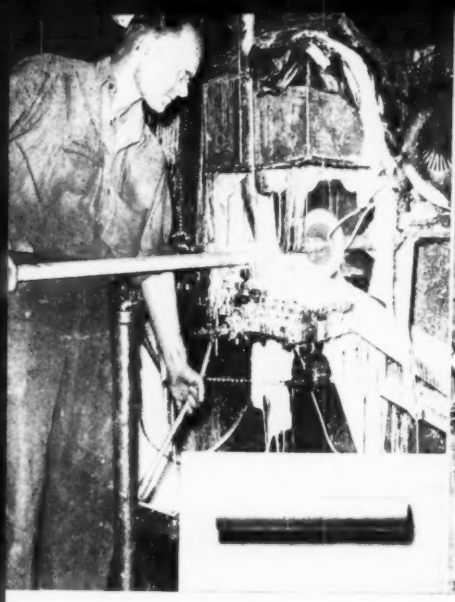
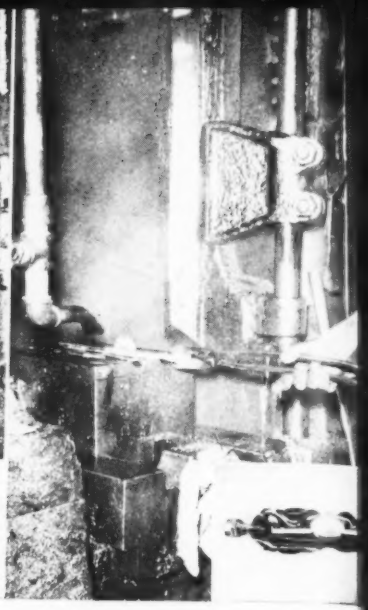
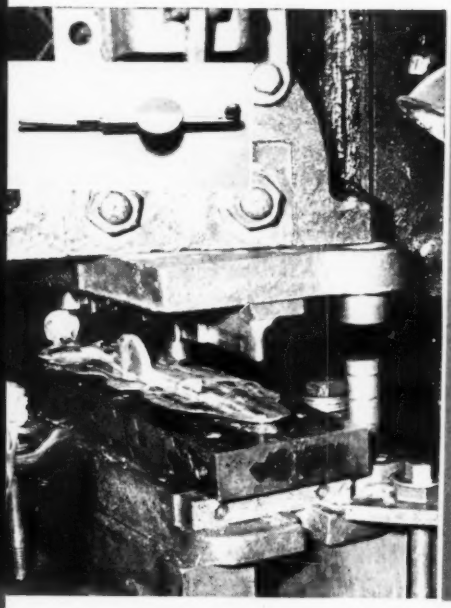


Cutting Bar

Lengthening and Shaping



Shaping to the Die



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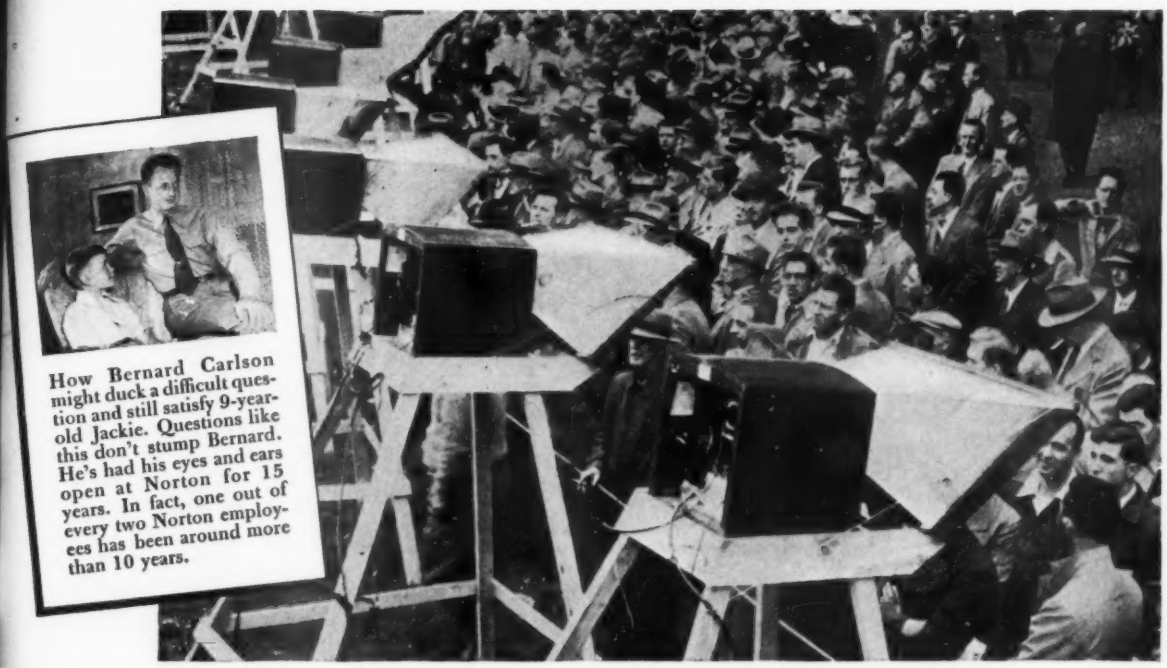

How Bernard Carlson might duck a difficult question and still satisfy 9-year-old Jackie. Questions like this don't stump Bernard. He's had his eyes and ears open at Norton for 15 years. In fact, one out of every two Norton employees has been around more than 10 years.

News photo of crowds watching television on Boston Common.

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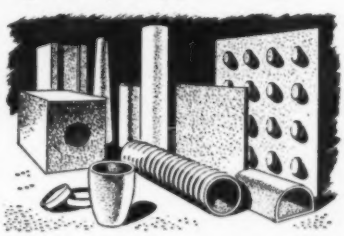

"Some people know Norton only as the world's largest maker of grinding wheels and machines, Jackie. But refractories in many sizes, shapes and materials are important Norton products, too. They're used in kilns, furnaces and ovens whenever industry wants to get the most out of high temperatures . . . safely."

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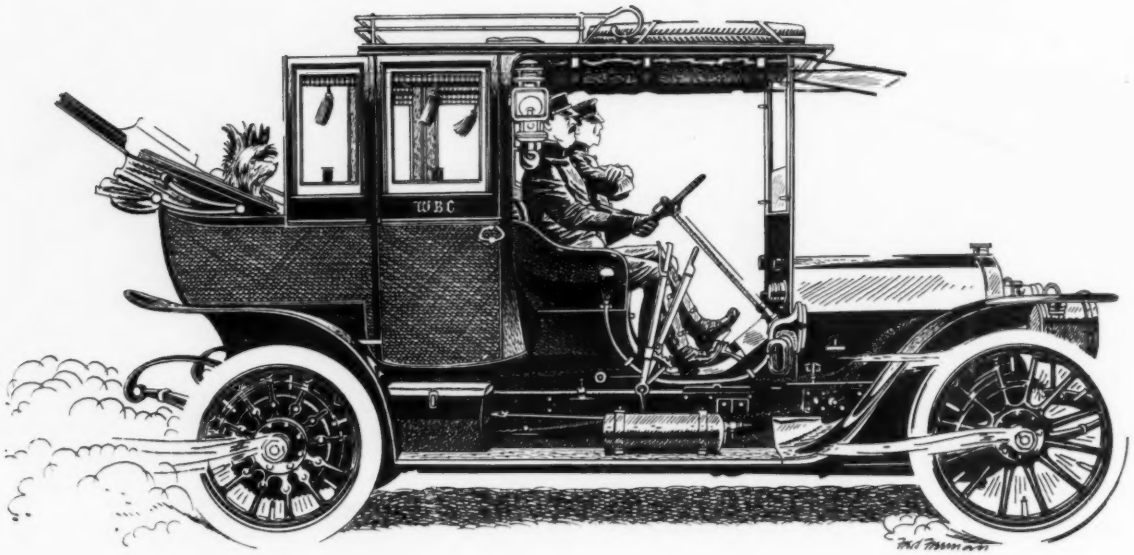

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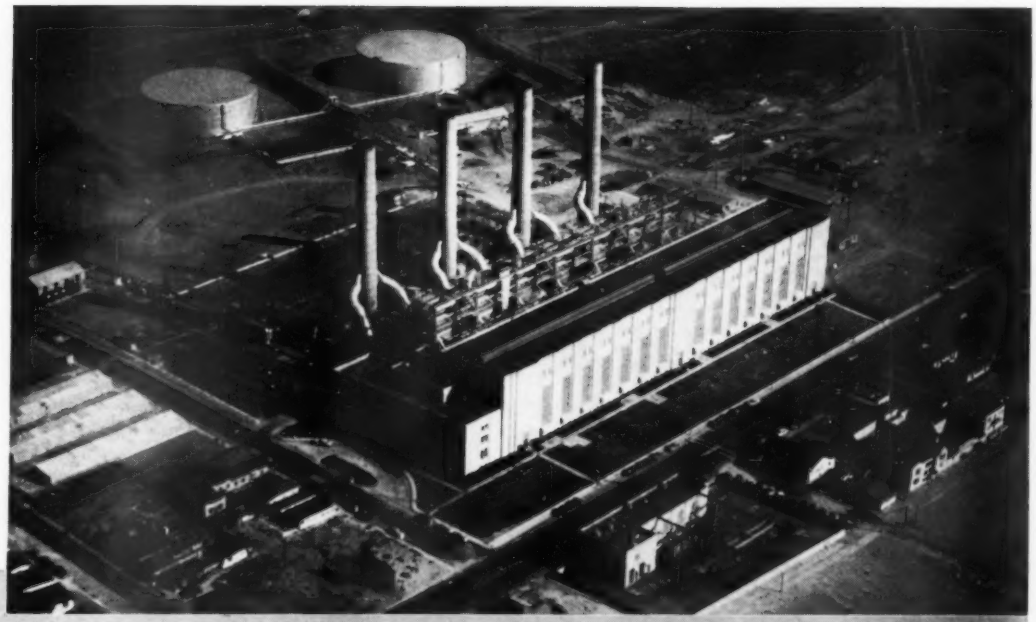

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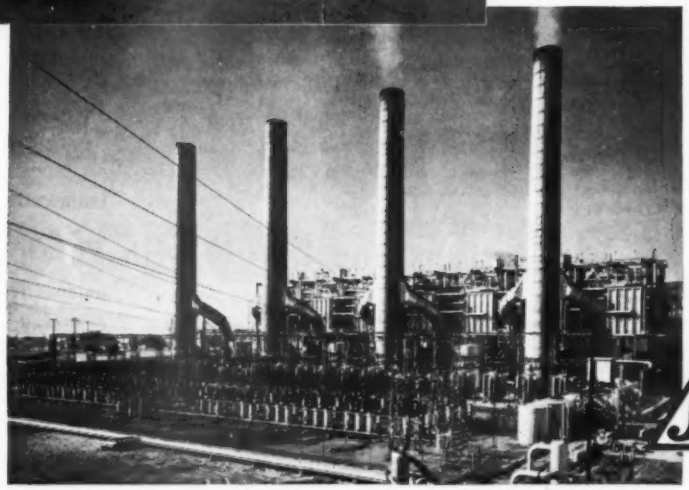

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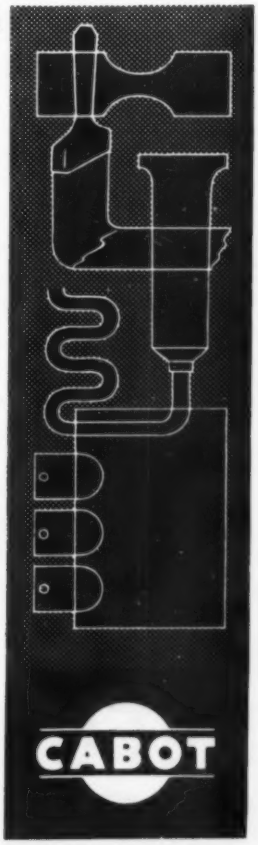

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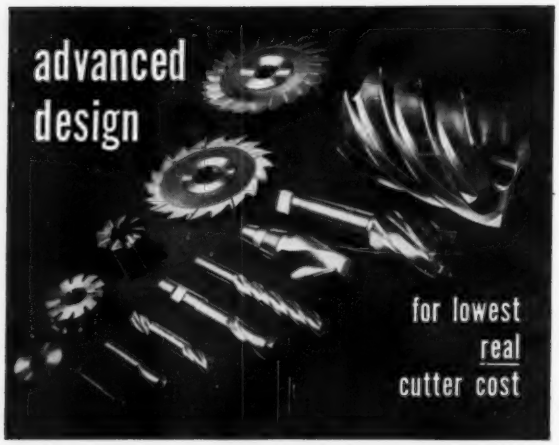

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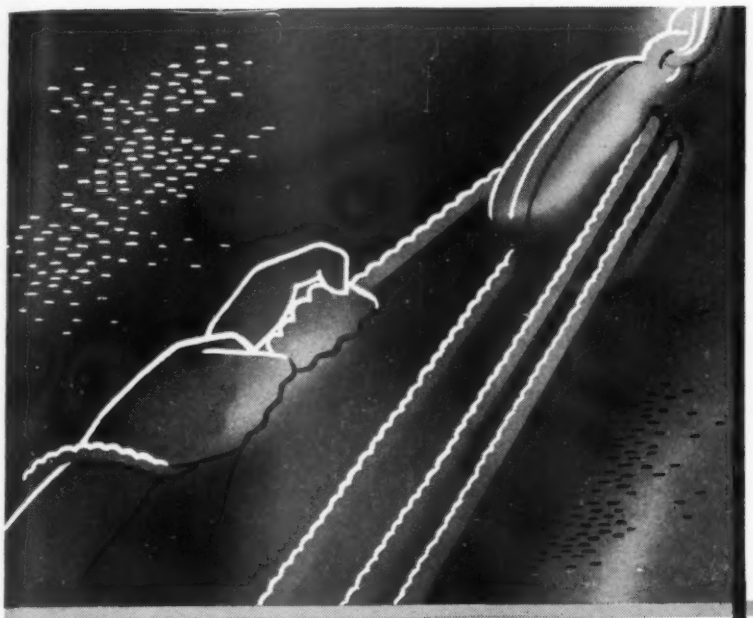
THE TABULAR VIEW

Initiative and Freedom. — In a convocation for M.I.T. students on December 5, VANNEVAR BUSH, '16, (following the roles of his ancestors which included clergymen, bank presidents, and whaling captains) warned future scientists and engineers of the dangers of soft security, surrender of individual self-reliance, scramble for subsidy, and the decline of the pioneer virtues which produced men of greatness. It is the privilege of The Review to bring to its Alumni (page 147) this message from Dr. Bush who has served M.I.T. between 1919 and 1938 as a professor in the Department of Electrical Engineering, dean of the School of Engineering, and vice-president. Since 1938 Dr. Bush has been president of the Carnegie Institution of Washington. During World War II he was director of the Office of Scientific Research and Development, and subsequently was appointed by President Truman as head of the Research and Development Board of the National Military Establishment. Few others are so well fitted by experience, insight, and sympathetic understanding to inspire a return to the virtues of an earlier day and to demonstrate that, in economics and in government, as well as in science, no path leads to "something for nothing."

Going Like Sixty. — At decennial intervals, H. E. LOBDELL, '17, has taken a look at the speeds with which passenger trains operate. His current examination (page 149), emphasizing the progress which has been made since 1940, highlights the fast tempo of the present era, and on the basis of trends well established, records the passing of the puffing, snorting iron horse. As an ardent student of American railroad operation, Mr. Lobdell has ample opportunity to observe firsthand the workings of this form of transportation, for as executive vice-president of the Alumni Association, he travels annually many thousands of miles to cement good fellowship between the Institute and its Alumni in M.I.T. clubs throughout North America. Mr. Lobdell has been closely associated with The Review for more than a quarter of a century — as editor and now as its publisher.

Twentieth Century Mid-Point. — The influence which science and engineering have had in shaping our present mode of living is surveyed (page 156) by PAUL COHEN, '35, whose thumbnail sketch of significant progress during the past five decades has been prepared especially for this issue of The Review. No account of half a century of change in the United States would be complete without some record of the progress which we have made in international affairs, in redistribution of wealth, and in piling up a huge public debt, but Mr. Cohen limits his discussion largely to the overwhelming accomplishments in science and industrial technology. An editorial associate of The Review for more than a decade, Mr. Cohen is by nature an acute observer, by training a mechanical

(*Concluded on page 136*)



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THE TABULAR VIEW

(*Concluded from page 134*)

engineer, and by inclination an interpretive writer on topics technological. Since his graduation from the Institute, Mr. Cohen has been, successively, an instructor in the Department of English and History at M.I.T., an engineer with the United Shoe Machinery Corporation, and now occupies an administrative and engineering position with the Sperry Gyroscope Company.

Depletion of Natural Resources. – The study of mineral depletion and metal supply which appears (page 158) in this issue of The Review was delivered by EVAN JUST at a symposium of the Institute's Department of Metallurgy some months ago. The inclusion of Mr. Just's study in the January issue is particularly appropriate, not only because the general theme of the issue is in the nature of a survey of our present world, but also because New York's current water shortage has drawn national attention to the need for conserving our natural resources. By training, Mr. Just is a geologist, having received his bachelor's and master's degrees in this field in 1922 and 1925 from Northwestern University and the University of Wisconsin, respectively. He became a petroleum geologist for the years 1922–1924 and again in 1928–1931. From 1925 to 1928 he was a geologist engineer and his explorations for bauxite, lead, and fluorspar took him to Brazil and Russia, as well as to various parts of the United States. He became assistant professor of geology and petroleum technology at the New Mexico School of Mines from 1931 to 1934, petroleum production engineer for the Carter Oil Company between 1934–1937, and secretary of the Tri-State Zinc and Lead Ore Producers Association between 1937 and 1942. Except for the past year when he was director of the Strategic Materials Division of the Economic Cooperation Administration, Mr. Just has been editor of the *Engineering and Mining Journal* since 1942.

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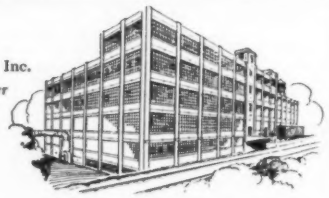

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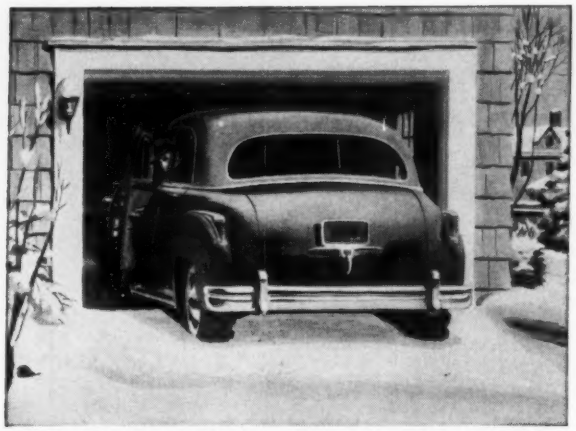

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Henry M. Mayer from Black Star

"Let us have peace."

— Ulysses S. Grant

THE
TECHNOLOGY
REVIEW

Vol. 52, No. 3 January, 1950

The Trend of Affairs

A New Half Century

This month the usual survey of anniversaries, which has opened the Trend of Affairs in January issues for years, is omitted in favor of a group of feature articles providing the more extensive examinations which befit inauguration of a new half century. The Review offers a thumbnail sketch of technological progress since 1900 by Paul Cohen, '35; an examination of passenger train speeds for a like period by H. E. Lobdell, '17; a note of caution on depletion of our minerals and metals by Evan Just; and an inspiring article by Vannevar Bush, '16, evaluating our present socioeconomic position.

Utilizing Beet Sugar Waste

Two beet sugar factories in Ohio and one in Michigan are now using a new process of utilizing waste waters previously discharged into rivers and streams. The reclaiming process, developed by Erman A. Pearson, '47, in the Department of Civil and Sanitary Engineering under the supervision of Clair N. Sawyer, Associate Professor of Sanitary Chemistry, ideally meets the requirements for waste disposal, since it reduces a major source of stream pollution and simultaneously improves economy of plant operation. In fact, preliminary economic studies of the process indicate that the savings effected during the first year of operation are sufficient to amortize the capital investment for the necessary treating equipment. The process is being studied by the United States Public Health Service because of its promise in reducing stream pollution.

In the usual process, sugar is extracted by passing water through large vertical tanks packed with shredded beets. When most of the sugar has been removed, the remaining beet pulp is washed from the tanks, after which it is drained, pressed, dried in a gas-fired rotary kiln, and sold as cattle feed. The wash water used to displace the pulp, as well as that removed from the pulp in the draining and pressing operations, is customarily discharged into streams. This waste water contains some sugar, considerable organic nonsugars both in solution and in suspension, and has a high bacteria count. For each ton of beets processed, yielding 250 pounds of refined sugar, the volume of waste water may be from 300 to 500 gallons, and it is often the most objectionable waste product that results from the process.

Re-use of the waste water by adding it to the fresh water used in the extraction process has not proved practical because the high bacteria content of the waste water causes fermentation with resultant generation of gas which greatly impedes circulation of the extracting liquid. In addition, fermentation destroys valuable sugar, thus reducing sugar yield. Furthermore, solids suspended or dissolved in the liquid interfere with circulation and, of course, necessitate additional processing in the treatment of the extract.

In the new process the waste water is treated with 35 to 45 parts (by weight) of chlorine per million parts of waste water, and its acidity is neutralized to maintain optimum *p*H by the addition of small amounts of lime. The chlorine destroys the bacteria and precipitates most of the organic nonsugars as well. It is then necessary only to provide tanks for coagulation and sedimentation of the solids, and the water is then ready to be added to the fresh water used for sugar extraction. The sediment can be removed to a storage lagoon for drying.

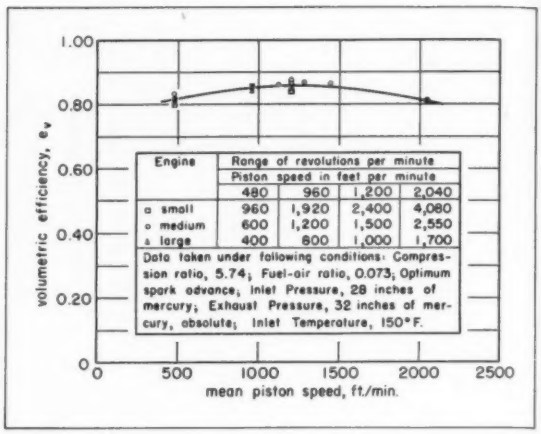
Besides eliminating a major source of stream pollution, the process improves plant economy by reducing the water needed for extraction by about 30 per cent and by increasing sugar yield from the beets. The recovery amounts to about four pounds of sugar for every ton of beets processed, or about 1.5 per cent. For a 1,000-ton mill, about two tons of sugar are saved per day which formerly were discharged into the river. Since there are about 80 sugar mills operating in the United States, the tonnage of sugar that can be saved annually is of considerable economic importance.

How Do Engines Grow?

In the Sloan Laboratories for Aircraft and Automotive Engines, research personnel are seeking fundamental answers to the question, "How do engines grow?" They hope to develop quantitative methods which will relate the various performance factors of such extremes as a one-sixth horsepower model airplane engine and a 10,000-horsepower Diesel engine.

Engines can be made to grow both by increasing the size of individual cylinders and by increasing the number of cylinders. Sloan Laboratory personnel, under the general direction of Professor C. Fayette Taylor, '29, of the Department of Mechanical Engineering, are exploring the effects of size changes in single-cylinder engines; for the more firmly the design factors in single cylinders are established, the fewer will be the uncertainties in the design of multicylinder engines.

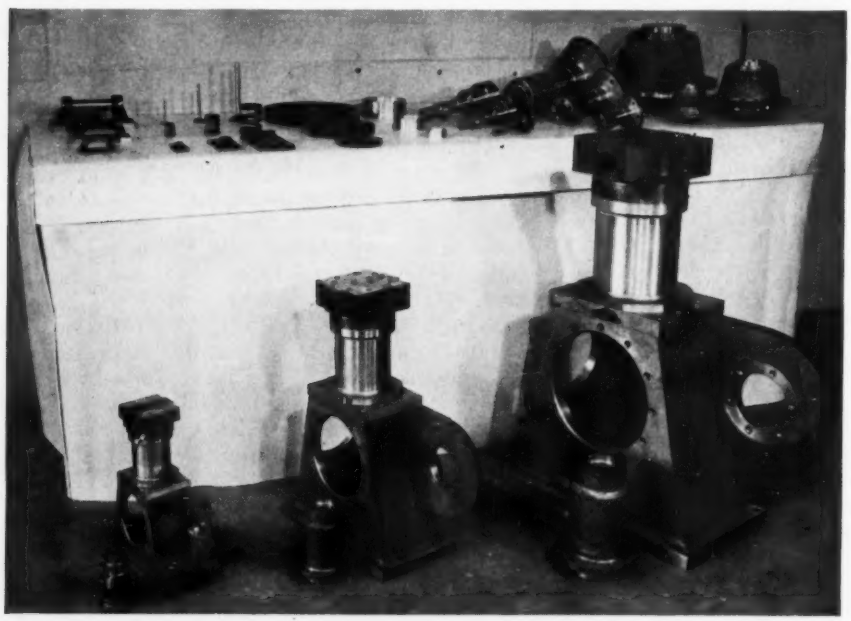
Up to the present time the basic effects of cylinder size have been appreciated only in a qualitative way by engine manufacturers, for no one has made a systematic quantitative study of this kind. This seems particularly surprising when it is remembered that nine-tenths of the nation's mechanical horsepower capacity is in internal-combustion piston engines. In determining such questions as what size cylinder to use or how long the piston stroke should be, designers are accustomed to making reasonable guesses based on a large amount of experience with equally empirical designs used in the past. The phenomenal success of existing designs, as exemplified by the modern highly efficient airplane engine, is more a tribute to the engineering intuition of the designers than to advanced knowledge of the fundamentals of engine design. It is believed that design factors can be put on a much more rational basis when the laws of similitude, that is, the relationships between a series of carefully scaled engines of different size, are accurately known. In other fields, such as hydrodynamics and aerodynamics, the laws of similitude were established long ago and have been of tremendous value in permitting designers to predict the performance of any size ship or airplane from test results on small models. There is no reason why a knowledge of the laws of similitude in engines should not yield equally effective results.



Volumetric efficiency plotted against mean piston speed for three geometrically similar single-cylinder engines.

To provide facilities for studying these laws, the design and fabrication of three geometrically similar single-cyinder engines with bores of two and one-half inches, four inches, and six inches diameter, respectively, were recently completed at the Sloan Laboratories and a test program is now under way. These engines are shown below, before trial assembly and mounting for test.

Theoretical analysis has already suggested the way many of the factors, such as air flow and stresses, should correlate, and experimental verification of these relations has already been obtained. For example, the graph shows that these engines have the same curve of volumetric efficiency (air intake volume divided by piston displacement) when the basis of plotting is the mean piston speed. This result was pre-



A group of single-cylinder engines, similar in every respect except in size, have been built in the Sloan Automotive Laboratory. Studies of the operation of these engines will enable designers to predict accurately the way in which performance depends upon size, since these are to be used in quantitative studies of the law of similitude as applied to the behavior of internal combustion engines.

The engines are shown before assembly and mounting on test stands. From left to right respectively, the bores are two and one-half, four, and six inches.

dicted from theory, but had never before been demonstrated experimentally.

Other factors, such as friction, lubrication, and heat losses have been subjected, in part, to theoretical analysis, but cannot yet be handled completely in this manner and require experimental data to complete the picture. Still other factors, such as "detonation," await experimental results before a quantitative correlation can even be proposed.

The program promises to enable designers to predict with precision the changes in performance of an engine as its size is changed. It will provide a quantitative basis for choosing optimum design parameters for greatest fuel economy, lightest weight, or minimum size. With the urge toward improved performance in all types of self-propelled vehicles, the importance of placing these basic concepts on a strong fundamental basis becomes increasingly urgent.

Iron Absorbed from Food

RADIOACTIVE tracer techniques are being used in nutritional studies of iron assimilation conducted by the Department of Food Technology, in collaboration with the Departments of Biology and Physics. The studies were undertaken to learn quantitatively how the assimilation of iron is affected by the foods with which it is consumed. It has been shown that oatmeal is no more detrimental to iron assimilation than are equal amounts of other foods, even though phytates, salts of a phosphorus-containing organic acid present in most cereals, markedly impede iron absorption when added separately to a meal.

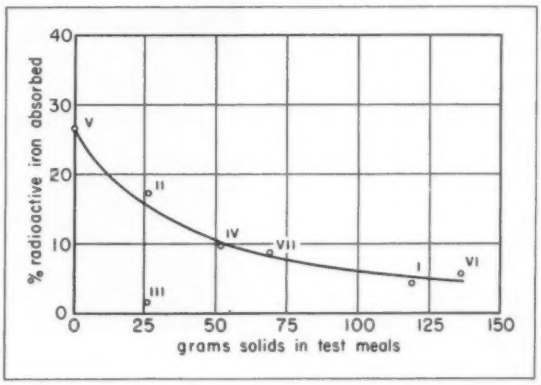
With the permission of their parents, 17 adolescent boys participated in the experiments on nutrition under the direction of Professor Robert S. Harris, '28, of the Department of Food Technology. The boys ate a breakfast which contained eight milligrams of iron. A small fraction of this iron – too minute to be harmful – was a radioactive isotope produced in a cyclotron and added in the form of ferric citrate or ferric chloride. The radioactive "tagged" atoms could easily be traced in their course through the body and were used to determine the amount of iron from the breakfast which appeared in the blood stream.

At intervals of several days after the breakfast, blood samples were taken and analyzed to determine how much radioactive iron was in the blood. When the iron absorbed had reached a steady quanitity, another breakfast containing radioactive iron was eaten. Altogether, seven breakfasts were consumed having the quantities of food given in the table.

Composition of the Test Meals (in grams)

Test Meal	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*
Milk	200	200	200	200		200	200
Water					200		
Cooked rolled oats	285			173		285	285
White bread	34					56	
Egg omelet	75					75	
Tomato juice	150					150	
Sodium phytate			0.2				
Total wet weight	744	200	200.2	373	200	766	485
Total dry weight (calculated)	119	26	26	52	0	136	69

Generally 10 days were required before all of the iron absorbed from a single meal reached an equilibrium quantity in the blood stream. Once in the body, no loss of radioactive iron was measured during a period of 175 days after a breakfast, at which time measurements were stopped. This is particularly remarkable since other tests have shown that the red corpuscles, containing most of the iron, are destroyed and remade on the average of once every 23 days. These results confirm those obtained concurrently and independently at another laboratory and may mean that the required daily intake of iron is much less than that previously thought necessary.



Of the amount of iron consumed with food, the fraction absorbed in the blood stream decreases with increasing size of meal.

The graph shows the fraction of the radioactive iron absorbed, plotted against the dry weight of the meal. It is evident that oatmeal had no greater effect on iron absorption than the other solid foods, whereas the sodium phytate very greatly decreased iron absorption. Since oatmeal contains phytates, it is evident that the phytates are not available to react with the iron during digestion.

Solid foods are shown to have a detrimental effect on iron absorption. Only one fifth as much iron was absorbed when taken with a full meal as when taken alone with a glass of water, suggesting that medicinal iron would be much more effective when taken between meals rather than at mealtimes.

The manner in which phytates affect calcium assimilation are now being investigated with the use of a radioactive isotope.

Perfecting the Gas Laws

OVER wide ranges of pressure and temperature, the densities of most gases approximate those predicted by the perfect gas law, for which theory assumes no intermolecular forces. At low temperatures or high pressures, however, the forces between molecules are of sufficient magnitude to cause large deviations in the behavior of a gas from that which is predicted by the perfect gas law. Various equations of state – mostly determined empirically, although guided by theory, of course – have been proposed which allow for the intermolecular forces. By correlating such equations of state with measurements of pressure, temperature, and volume for gases, the theory by which the equations have been derived can

be tested and the magnitude of the intermolecular forces can also be evaluated. Ultimately it should be possible to establish gas laws which are valid for all conditions of pressure, temperature, and volume, either for pure (single compound) gases or for mixtures.

With this ultimate goal in mind, research workers, under the direction of Professor James A. Beattie, '17, in the Department of Chemistry are now engaged in a program of extremely accurate measurements of densities and associated properties of gases, such as critical points and vapor pressures. Means for accurate determinations of gas densities have been developed and refined by Professor Beattie over the past 20 years. To make a density measurement, a known mass of substance is transferred to a steel bomb whose temperature is controlled to within 0.001 degree C. of the desired temperature. The density of the substance is varied by forcing a known amount of mercury into the bomb, and the pressure is measured by dead weight pressure gauges. By this means the error in measurement of gas density has been reduced to less than one-tenth of one per cent, producing results of value for testing certain postulates of the kinetic theory of gases and theories of state.

Herbert Matter from Black Star

Precision

High precision determinations of gas densities, critical points, and vapor pressures, provide basic information required both by the practical engineer in his design calculations for distillation and high-pressure processes, and by the theoretician in his effort to understand the forces between molecules. Precise measurements of gas density have direct industrial application in high-pressure processes, such as the synthesis of ammonia where the perfect gas law is greatly in error. In addition to indicating the size of equipment needed for a quantity of gas, such measurements are used to derive the thermodynamic properties of gases, for the prediction of chemical equilibrium, and of the heat and work effects involved in various processes. In calculations of distillation processes, this type of data is also required.

In a long-term research program now in progress, pressure, volume, and temperature relations and vapor-pressure data have been determined for such pure gases as ethane, propane, 1-butane, *n*-butane, isobutane, *n*-pentane, neopentane, *n*-heptane, ethyl ether, xenon, and krypton. The research is now being extended to the study of the density of gas mixtures.

Already mixtures of *n*-butane with methane, exemplifying a mixture of similar molecules (both nonpolar) have been studied. Measurements are now being started on mixtures of methane and chloromethane, as examples of two gases of different types of molecules (nonpolar and polar). These measurements can be used to test various procedures for combining the constants of the equations of state for the pure components in order to obtain comparable data for gas mixtures. The determination of density for mixtures is such a formidable task that an accurate method of prediction from data on the pure gases is of extreme practical importance.

At the present time, one of the most satisfactory equations of state for simple gases expresses relations between temperature, pressure, number of mols of gas present, and other gas constants, more or less empirically in a series of four terms. The inclusion of a term containing the fourth power of volume is justified only by the availability of data sufficiently accurate for the purpose.

When more than one gas is present in a given volume, the properties of the mixture become even more difficult to predict since the intermolecular forces now act not only between the same but different species of molecules. In some cases, a gas may "dissolve" in another gas much as salt dissolves in water without greatly changing the resulting pressure. This is true for the case of water vapor in air. If air is forced into a container of water in equilibrium with its pure vapor, more water will evaporate, partly because of the slight increase in vapor pressure caused by the increase in total pressure of the system, but partly because water vapor will dissolve in the air. At high pressures, this latter effect can be very large.

It may be a long time before the work now in progress is brought to the desirable degree of completion. In the meantime, industrial practice and theory alike will make some progress with every step which is made in perfecting the gas laws.

Renascent Antiquity

THE information clerk in a modern department store can readily direct inquirers to articles made of cotton, linen, silk, wool or other animal hairs, rayon, or nylon, and perhaps glass or metallic textiles; but in even the largest and best stocked of stores, a request for anything woven of *ramie* will probably be met by puzzled bafflement. Yet ramie is a fiber, with certain uniquely valuable characteristics, that has been known to man since the time of predynastic Egypt. Why then has this textile remained so obscure? First, because originally ramie fiber could be freed from the plant in which it grows only by tedious hand labor. Secondly, because ramie suffers from what is called, in the jargon of the textile industry, "low spinning quality." Recently, however, much technological progress has been made in overcoming both of these difficulties.

Ramie comes from a shrub, *Boehmeria nivea,* that is related to the nettles although it has no stinging hairs. These plants are hardy perennials that live as long as 30 years, and produce as many as four crops each season. The ramie shrub grows readily in the warm temperate zone throughout the world. It is easily propagated by dividing roots and replanting. Weeding is unnecessary. Yield per acre is high – up to 10 times that for cotton.

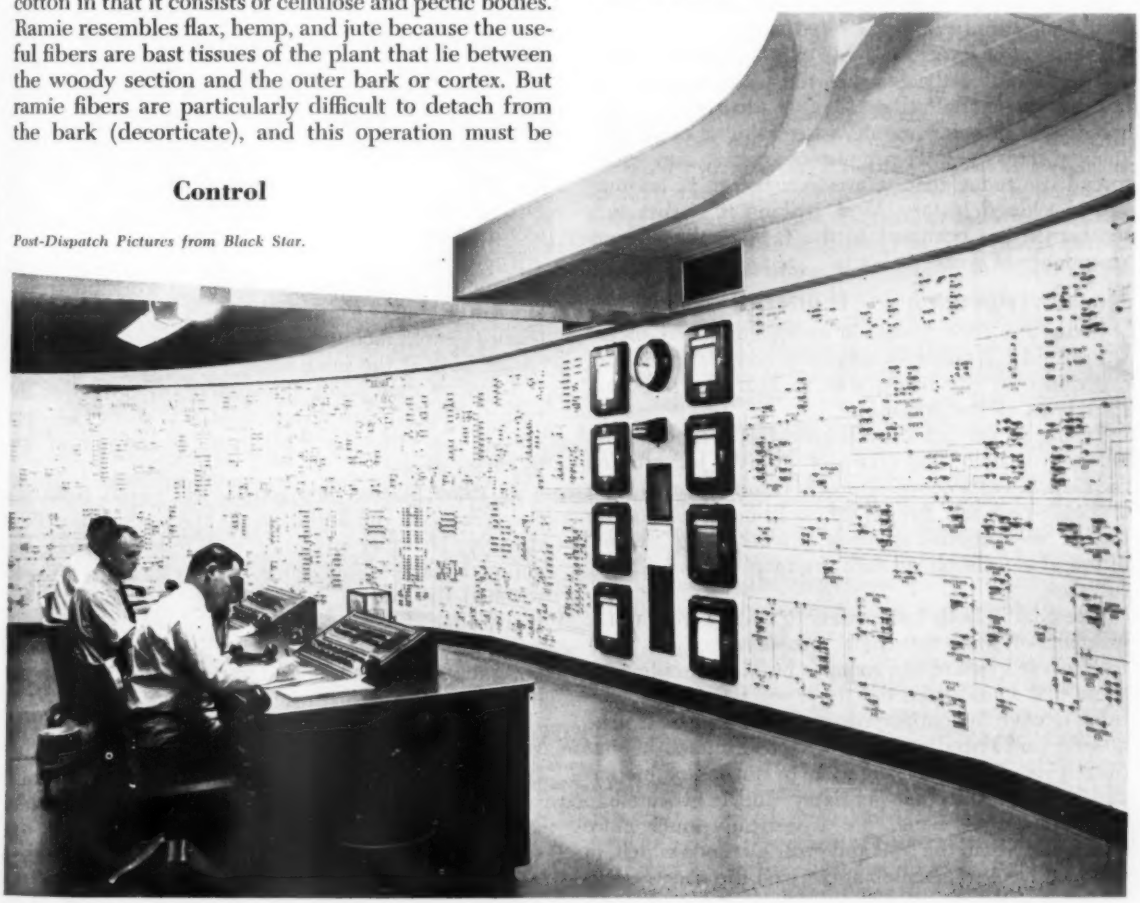
In composition, ramie is allied to flax, hemp, and cotton in that it consists of cellulose and pectic bodies. Ramie resembles flax, hemp, and jute because the useful fibers are bast tissues of the plant that lie between the woody section and the outer bark or cortex. But ramie fibers are particularly difficult to detach from the bark (decorticate), and this operation must be done within a short period after harvesting, before drying occurs. Until recently the only known means of decorticating ramie was tedious pounding by hand, and hand stripping of the fibers. Therefore, production was confined to countries like China where hand labor is cheap. In this primitive processing, removal of the tenacious resinous gum that surrounds ramie fiber was accomplished by prolonged soaking in water.

One of the potential values of ramie stems from the fact that it is by far the longest of the vegetable fibers, having an ultimate fiber length averaging 120 millimeters (as compared to only 28 millimeters for cotton or flax). But offsetting this virtue is the extraordinary variability of ramie. Thus these fibers have a range of 140 millimeters from shortest to longest, whereas cotton has a corresponding variability of only 30 millimeters; flax, 50 millimeters. In consequence, ramie until recently could be made only into coarse and hairy textiles, and used in limited applications, such as canvases or fire hose.

But ramie is lustrous, soft, and elastic, dyes readily, and has low shrinkage and high resistance to abrasion and mildew. Therefore, in recent decades, research aimed toward improvement of ramie processing has never flagged. One recent advance has been successful mechanizing of ramie decortication. Beyond this, decorticators have been designed on the "combine" principle, so that they operate right in the fields – harvesting and decorticating in one continuous op-

Control

Post-Dispatch Pictures from Black Star.



eration. One of these decorticators, operated by eight men, is reported to produce a ton or more of fiber every two hours. This output is in striking contrast to that of the old hand methods, whereby the same number of men working a full day could produce only a few hundred pounds.

It has also been discovered that treatment with hot caustic solutions under high pressure will degum ramie without affecting the fibers. Neutralization, washing, and drying then prepare the ramie for spinning. Improvement of the spinning of ramie has grown from realization that neither conventional cotton-spinning machinery, nor standard wool-spinning equipment, are satisfactory for such use. As a result a novel spinning principle has been developed, that nevertheless may be applied by remodeling existing cotton-spinning mills. This advance has made possible production of Number 80 count ramie thread – several times finer than could formerly be spun. Such fine thread puts ramie in a position to invade the clothing, bed and table linen, and related fields, as well as to become a useful component of mixed textiles.

In anticipation of increasing use of ramie, extensive acreages of the shrub have been planted in the United States, principally in California, Texas, and Florida. The alluvial muck lands of the latter state have proved to be especially favorable for ramie cultivation. This new crop has been fostered by Federal and state departments of agriculture.

At the moment, ramie is still a minor element in the total fiber supply of the United States. Recent announcement of foreclosure sale of an important ramie mill in Florida indicates that the promoters of this textile have not left their days of adversity entirely behind. Nevertheless, ramie, a natural fiber of ancient lineage, shows greater promise of coming into widespread use today than it ever has before in its long and checkered history. How striking it is that this renascence has occurred in the face of the current ascendancy of synthetic fibers.

Model Approach to Acoustics

COMBINING their talents in architecture and acoustics, M.I.T. students may help end that annoying experience of not being able to hear the principal speaker in an auditorium.

Trying to predict the acoustics of an auditorium before it is built, one group of students has studied the behavior of a pencil-size light beam reflected from a highly-polished ceiling of a 12-inch auditorium model. Now, another group is at work using "beams" of sound in a simplified auditorium model one-fifth of full size.

The goal in both instances is to make a very quick estimate of some acoustical properties of an auditorium even before the room is built. If simple tests show that sound from the stage will not spread adequately over the entire proposed room, plans can be altered, and tested again, before construction begins. Such preliminary investigation by means of models can be done quite inexpensively, and is expected to result in designs which are acoustically much more satisfactory than the trial and error methods which, in the past have so often characterized the construction of music halls.

The method involving the light beam is based on the fact that (within certain limits) sound waves reflect from a wall in much the same way that light rays reflect from a mirror. Thus, a beam of light is made to take the part of sound waves in the optical analogue of an acoustic system. Light beams, reflected from mirrored panels in the model, show the paths which sound waves would take in the full-size auditorium. The paths of light beams are recorded on photographic paper to produce a permanent record for analysis or comparison with other arrangements.

Such an optical analysis saves the tricky graphical manipulations which are needed to study sound distribution from blueprints by more conventional methods. It gives better precision and could be developed into a rapid tool for aiding directly the development of new auditorium designs by permitting quick, comparative exploration of a succession of auditorium shapes with relatively simple models.

Another method of analyzing the acoustic properties of auditoriums through the models, but employing acoustic rather than optical analysis, is now under investigation. Making full use of the law of similitude, the "sound analysis" system is based on the fact that a high-pitched sound will behave in a small model just as a normally-pitched sound will behave in the full-size prototype. In this case the model – although larger than that required for optical analysis – can be very simple, and thus inexpensive, while still giving all needed information.

These two systems are both recent projects of students in an M.I.T. graduate course in architectural acoustics. Under the supervision of Richard H. Bolt, Associate Professor of Physics and Director of the M.I.T. Acoustics Laboratory, and Professor Lawrence B. Anderson, '30, Head of the School of Architecture, the class is guided by Robert B. Newman, '49, an M.I.T. graduate just beginning service on the architectural teaching Staff.

The class is very definitely part of the educational program. But attempts are made to work out problems in architecture and acoustics in new ways, to teach research techniques as well as to establish principles, both at the same time.

To prove their point, the students who devised the reflected light-beam system used it to study the right kind of roof shape for a 1,000-seat auditorium of fan-like floor plan.

In some places, they found, the sound from the stage reached the audience on the auditorium floor directly. In other places it was reflected from the ceiling back to the audience; in still other cases, sound reached the audience after having bounced off the rear wall.

In any well-designed auditorium, the ceiling and walls must reflect the sound so that it is spread evenly over the entire area seating the audience. In addition, the reverberation time – the time required for the sound to reach one millionth of its initial intensity – of the reflections from ceiling, walls, and floor, must have the proper value for auditoriums of different size. The methods of analysis used by Institute students provide a highly convenient and useful means of quickly arriving at much significant data in the proper acoustic design of auditoriums.

The Essence of Security

A People Voting Themselves into Eden from a Supposedly Inexhaustible Purse Are No Match for a Dictatorship

By **VANNEVAR BUSH**

You men to whom I speak, as students at M.I.T., are nearly all scientists and engineers, or at least you expect to be. In these capacities, your function will be to understand the physical world, and on that basis to build, to raise standards of living, to further prosperity, and thus to assure the general condition of decency by which cordiality and understanding among nations may be fostered. Engineers and scientists, as you hope to be, are skilled in objective reasoning. In particular, they usually can add two and two, and get four. As an exercise in addition, I would place before you a few important items of recent news. They are digits in a sum, or factors in an equation. As is too often true of these things, they may not at first glance appear to be related.

First, President Truman recently expressed the conviction that the total income of this country, now over 200 billion dollars a year, should be raised to 300 billion dollars a year. National output normally increases 2 per cent a year because of technical advance; it is now probably increasing 3 per cent a year because of greater reliance on research since World War II. In less than a generation this factor alone can bring about the increase called for. But the President had in mind no such interval; he calls on us to move much faster toward a highly desirable end. While he spoke in terms of dollars, he undoubtedly thought in terms of product and services, of which dollars are merely a measure. It would be possible in a year or two to reach the 300 billion mark by merely voting wide Federal benefits and increased taxes, thus reaching an output at once of 300 billion dollars worth $0.40 each. He had in mind something more real than this.

Second, when the last Congress adjourned it faced a national deficit of six billion dollars. It had in the hopper ready for enactment nine billion dollars more of expenditure for divers good causes. One bill in process would have furnished Federal aid to the states in the form of architectural services. There were dozens more. The Federal government now supports or subsidizes in one way or another more than a quarter of the population, if one includes those indirectly dependent on the subsidy. The nine billion would have increased this fraction significantly. Congress adjourned temporarily and will be back in a month.

The next item comes from overseas. England is short of fats. Africa has enormous areas of fertile uncultivated land. The labor government recently spent £20,000,000 to start raising peanuts in Africa and extracting the oil. The governmental agency built docks, roads, schools, hospitals, housing, and acted throughout for the benefit of the employed. It didn't raise any peanuts to speak of. It is approaching the end of its funds, and admits it will not raise many peanuts. The House of Commons declines to investigate.

The last item is fresh in your minds. President Truman recently announced that there was an atomic explosion in the heart of the Eurasian continent.

Now are these items connected, and do they mean anything to you personally? Moreover can you do anything about it?

There is a connection among the items I have mentioned. They mean much to you, and to all of us. You can do something about it, and if you are as clear-headed as I think you are, you realize not simply that you can, but that you must. Each of them bears directly on the fundamental question of our times – the strength of the free democratic system as compared with the strength of the totalitarian system, and the ability of each system to grow in strength in the years to come. Until such time as reason and good will prevail, and a rational answer to the problem of live and let live in a complex world is established, this comparative estimate will stand as the most important imponderable in the world's vocabulary. By and large, all questions of policy, national or international, economic or political, immediate or long-range, take on importance and urgency to the degree – and only to the degree – that they bear on this basic issue.

Russia is a closely controlled dictatorship, a police state, with full ultimate management of the details of the life of every citizen. It can hold, and has held, the standard of living down to a small fraction of ours, denying its people the simple comforts of existence, in order to focus effort on guns and atoms. In the long run a totalitarian state cannot compete with a free people in the advancement of science, for dictation and dogma are contrary to the free spirit of inquiry, which is the heart's blood of scientific advance. But, in the short run, it can produce what it wishes to produce, and ignore the sufferings of its people, up to a limit, and that limit is high. It can produce an atom bomb, and has done so. In time, how much time is arguable and important, it can produce a stock of atomic bombs.

The atomic bomb does not stand alone. It is not an absolute weapon. It is part of a vast and intricate armament, and much of the nature of that armament was spread out for all the world to see in World War II, and is known to many technicians in

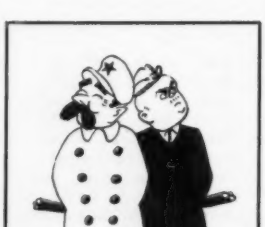
The text of Dr. Bush's challenging address to the student body of the Massachusetts Institute of Technology, in convocation on December 5, is presented with but minor editorial emendation. — Ed.

Russia as elsewhere. Russia can build fleets of bombers, jet aircraft for defense, radar networks, as well as guided missiles.

But can it build all these at once, in ample quantities, in reliable form, operated by well-trained men of initiative and resourcefulness? The answer to this question depends upon what one believes the Russian economic system can stand without collapse. But, whatever the estimate, there is no doubt that Russia can build, and is building, a formidable military machine. Whether it does so from genuine fear of attack, or in a dream of conquest, is beside the question; we face the fact that, barring an improbable early internal collapse, such armament will appear in the hands of an absolute closely knit central governing group of men who distrust us and would destroy us if opportunity offered.

We can meet that threat if we are strong. We can in fact meet it without war, for those in the Kremlin recognize strength if they recognize nothing else. The fact that we can meet it was recently proved when this country, bringing to bear on grim business the resourcefulness and initiative nurtured in freedom, armed its allies and joined with them to strike down the Nazi might.

But we cannot meet it if we turn this country into a wishy-washy imitation of totalitarianism, where every man's hand is out for pabulum, and virile creativeness has given place to the patronizing favor of swollen bureaucracy. Dictatorships can compete with dictatorships, and free virile democracy can outpace any such in the long pull. But a people bent on a soft security, surrendering their birthright of individual self-reliance for favors, voting themselves into Eden from a supposedly inexhaustible public purse, supporting everyone by soaking a fast disappearing rich, scrambling for subsidy, learning the arts of political logrolling and forgetting the rugged virtues of the pioneer, will not measure up to competition with a tough dictatorship. If we go all the way down the path to dependence and render ourselves a people fawning for handouts on an intriguing bureaucracy, Russia can cease its building of war machines. It will conquer the world without them.

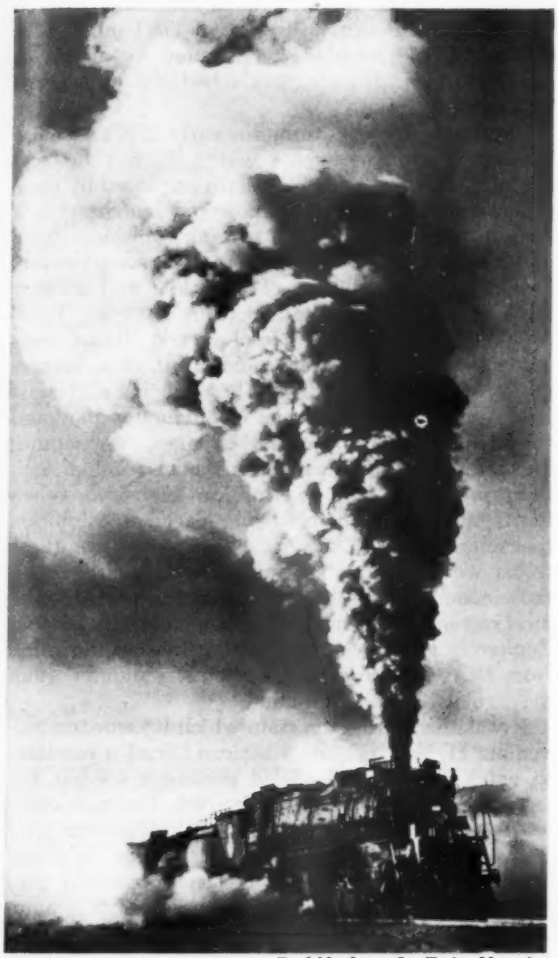


Now I am no pessimist. I believe in the democratic system, and I believe in the sound common sense of the American people. Moreover, I believe thoroughly that we have the wit to recognize a dangerous trend, reverse it before it is too late, and laugh at sirens with crackbrained economic theories who would guide us down an easy path over a precipice. I believe also that the past generation, with a rise in the power of the common voter, and an increase also in his perception and grasp of public affairs, has brought with it highly salutary progress toward protection of the small man against the hazards of nature or of his grasping neighbor. We live in a better world because of awakened public consciousness of its power and its possibilities. We have done much for the underprivileged and more for the laborer at the bench, and it is well. But we can outpace ourselves, attempt too much, and wreck the industry on which all material progress depends. Still I believe the American people are too tough minded to pursue a will-o'-the-wisp over a cliff. I know they can add, and I do not believe they are fooled by stories of magic wands or of inexhaustible treasures. If I am wrong, we are in for disaster.

But my main point today is to ask what you men propose to do about it. Some of you will differ with my point of view quite completely, but no matter. I ask what you propose to do about your own theory of the dilemma and its solution. Unless you take the naïve point of view that the building of a powerful military machine overseas is no concern of ours (and that delightful fiction seems to have disappeared even from the ranks of the isolationists) there is something to be done. Unless you take the equally naïve point of view that this is an affair for our own military men and no concern of the private citizen, you have a problem squarely on your doorstep. Moreover it is peculiarly yours — for the strength of this country means more than arms and services, it involves the entire strength and prosperity of the country, which is a matter directly in your area. The question is whether you will be content to build in a technical sense, and let someone else worry about the larger problems.

Some of you, unhappily, will spend your time and effort exclusively in passing technical courses, and thoroughly shun those dealing with man's relation to man. You will pay not the slightest attention to the political maelstrom about you, and look down on those who take an interest in politics, or who have the hardihood actually to practice it. You will regard such things as history, economics, mass psychology, foreign relations, as soft generalizations, not worthy of the steel of the man who can manipulate a Fourier integral. Or at the other extreme some will browse in generalities and amuse yourselves with vague nonrigorous speculations and know nothing of a Fourier in-

(*Concluded on page 168*)



Fred Matthews, Jr.: Trains *Magazine*

The Fastest Trains

A Survey of the Increases in Speed over High Iron during the 1940's

By H. E. LOBDELL

EVEN as opinions ventured about tomorrow's weather, claims about how fast one can go from here to there, on trains publicized as being ultraspeedy, have provoked and sustained many a contentious discussion ever since railroading began. Each topic offers a natural conversational gambit affluent in potential pros and cons, the amplitudes of which are perennially enlarged through the observance of newer data.

For instance, back in 1933 the aggregate train mileages, booked to operate from start to stop in the United States, France, Great Britain, and Germany at 60 miles an hour and over, totaled 10,571. More than half, 5,462 miles to be exact, was accounted for by runs on French railways, and only a fifth, slightly over 2,000 miles, by those in the United States. In the next five years, the 10,571 figure increased eightfold, to a total milage of 84,659 for the four countries, and the world mileage run in excess of a mile-a-minute average stood at 93,312. Of the 1938 world's total, more than half, 48,164 miles, was booked on American rails. France stood second with 14,594 miles, Great Britain third with 11,665, and Germany fourth with 10,236 miles.

Corresponding statistics of 1943, the end of the ensuing five-year period, are unavailable except for the United States; and by 1948, postwar railway recovery in Europe had not progressed sufficiently to permit then current British or French figures being treated as significantly comparable with those for the United States. In the table "Ten-Year Advance . . ." it will be noted, however, that the aggregate American mileages scheduled for at least 60 miles an hour advanced from 48,164 in 1938 to 92,118 by 1943 (an increase of 91 per cent), and to 129,172 by 1948 (an increase for the decade of 168 per cent).

Data in the table also definitely show Diesels were the leading form of 1938–1948 railroad motive power for mileages scheduled at 70 miles an hour and over; and how Diesels overtook steam for the 60–70 miles an hour range by the close of 1943. But steam's amazing displacement on American rails between 1943 and 1948 – 6,888, or 17 per cent, fewer steam locomotives in the 1948 inventories, which included 3,730, or 141 per cent, more Diesel and electric locomotives – has not come about wholly by the predominance of the Diesel in high-speed operations. Today, Diesels are common on many slowpoke secondary lines, such as on the Washington County branch of the Maine Central at the head ends of locals meandering down East from Bangor to Calais. For, among its other advantages under actual operating conditions, a single horse-

Ralph E. Hallock: **Trains *Magazine***

power of a Diesel can perform the tasks hitherto expected of approximately two and four tenths of a steam locomotive – because the Diesel, unlike the iron horse, does not have to be withdrawn from the road periodically to be "fed, watered, and rested."

In 1932, there was only one train in the world with a timetable calling for it to maintain a nonstop run between two stations at an average of at least 70 miles an hour. This was the Great Western's *Cheltenham Flyer,* which in that year was speeded up to cover the 77.3 miles from Swindon to Paddington Station, London, at a rate of 71.4 miles an hour instead of its previous average of 66.3. Less than a year later, however, the *Deutsches Reichsbahn* put in service *Fliegende Hamburger,* a two-car, articulated auto train between Hamburg and Berlin, a distance of 178.1 miles. This original *Flying Hamburger,* powered by a pair of 410-horsepower Diesels, was scheduled to average 75.8 miles an hour.

Cisatlantic interest during the early 1930's was also focused upon experiments which, it was fancied, might develop the Diesel (hitherto employed by some American railways for light-powered switchers) as a form of motive power able to rank alongside steam and electric locomotives in general passenger and freight service. Delivery of *M-10,000* and *Pioneer Zephyr,* two experimental, specially designed, lightweight, high-powered Diesel-electric trains, was made to the Union Pacific and Burlington, respectively, in the spring of 1934. These elegant and shiny streamliners, the first named of aluminum alloy and the other of stainless steel, in their outside appearance and interior appointments were indeed unlike anything previously seen on American high iron. When touring the country before being placed on exhibition that summer at the Chicago Century of Progress, these trains were tested at sustained speeds far beyond those commonly run by ordinary trains; probably the most memorable of such trials being a run by *Pioneer Zephyr* in May, over 1,000 miles nonstop, downhill from Denver to Chicago in 13 hours, 5 minutes, at an average of 77.6 miles an hour.

It was this Burlington train which became, on November 11, 1934, the first American Diesel streamliner to enter regularly scheduled passenger service, between Kansas City and Lincoln, Neb. Union Pacific's *M-10,000* was the second, less than three months later between Kansas City and Salina, Kansas, in honor of which western terminal it was rechristened *City of Salina.* The first streamliner with sleeper accommodations, a seven-car Diesel train, began its original schedule of five round trips a month between Chicago and Portland, Ore., on June 6, 1935, under the name of *City of Portland.*

Although in day-to-day operation none of these three trains at the start promised patrons a ride between stops at more than 60 miles an hour, their actual

Ten-Year Advance (1938–1948) in Aggregate Train Mileages Booked to Operate Daily in the United States from Start to Stop at 60, 70, and 75 Miles an Hour and Over

(Based upon data for 1938 and 1943 compiled by *Railway Gazette,* London, and for 1948 by *Railroad Magazine,* Chicago)

Daily Runs At and Over		1938	1943	1948	*Five-Year Changes* 1938–1943			1943–1948			*Ten-Year Changes* 1938–1948		
60 m.p.hr.	Diesel	14,840	36,553	91,434	up	21,713	(146%)	up	54,881	(150%)	up	76,594	(516%)
	Steam	23,692	38,570	18,966	up	14,878	(63%)	down	19,604	(51%)	down	4,726	(20%)
	Electric	9,632	16,995	18,772	up	7,363	(77%)	up	1,777	(10%)	up	9,140	(95%)
	Totals	48,164	92,118	129,172	up	43,954	(91%)	up	37,054	(40%)	up	81,008	(168%)
70 m.p.hr.	Diesel	3,273	6,790	14,651	up	3,517	(108%)	up	7,861	(116%)	up	11,378	(348%)
	Steam	960	1,993	59	up	1,033	(108%)	down	1,934	(97%)	down	901	(94%)
	Electric	182	419	228	up	237	(130%)	down	191	(46%)	up	46	(25%)
	Totals	4,415	9,202	14,938	up	4,787	(108%)	up	5,736	(62%)	up	10,523	(238%)
75 m.p.hr.	Diesel	982	1,806	3,194	up	824	(84%)	up	1,388	(77%)	up	2,212	(225%)
	Steam	—	212	—	up	212	—	down	212	(100%)		—	
	Electric	30	—	—	down	30	(100%)		—		down	30	(100%)
	Totals	1,012	2,018	3,194	up	1,006	(99%)	up	1,176	(58%)	up	2,182	(216%)

Trains Booked to Operate Daily in the United States From Start to Stop at 75 Miles an Hour and Over in October 1949

(Compared with the fastest daily trains scheduled on these runs in 1939)

1949 Train and Railroad	*Terminals of Run*	*Mileage of Run*	**1949** *Minutes-Direction-Miles an Hr. Averaged*	**1939** *Minutes-Direction-Miles an Hr. Averaged*	*1939 Train*
New England States New York Central	La Porte-So. Bend	26.7	19–E–84.3 21–W–76.3	29–E–55.2 28–W–57.2	No. 614 *Iroquois*
Morning Zephyr and Afternoon Zephyr Burlington	E. Dubuque-Prairie du Chien	54.6	39–N–84.0	44–N–74.4	*Morning Zephyr* and *Afternoon Zephyr*
	La Crosse-Prairie du Chien	57.7	42–S–82.4 44–N–78.7	52–S–66.5 53–N–65.3	
	No. La Crosse-Winona Jct.	26.9	20–N–80.7	23–N–70.1	
	Aurora-Oregon	60.4	48–N–75.5*	52–N–69.7	
City of New Orleans Illinois Central	Kankakee-Rantoul	57.9	42–S–82.7		
Morning Hiawatha Milwaukee	Sparta-Portage	78.3	59–S–79.6		
Panama Ltd. Illinois Central	Kankakee-Champaign	72.0	55–S–78.5	85–S–50.8	*Panama Ltd.*
City of Milwaukee Commuter "400" Northwestern	Kenosha-Waukegan	15.7	12–S–78.5	16–S–58.9	*The Valley* No. 206 No. 214
Cities of San Francisco, Los Angeles, and Portland Union Pacific	Grand Island-No. Platte	137.2	*SF*:105–W–78.4 *LA*:105–W–78.4 *P*:107–W–76.9	114–W–72.2 114–W–72.2 115–W–71.6	*Cities of San Francisco, Los Angeles, and Portland*
	Cheyenne-Sidney	102.0	*SF*:79–E–77.5 *P*:79–E–77.5	86–E–71.2 86–E–71.2	
Afternoon Hiawatha Milwaukee	New Lisbon-Portage	43.1	33–S–78.4	35–S–73.9	*The Hiawatha*
Empire Builder Burlington	E. Dubuque-La Crosse	112.3	86–N–78.3		
Olympian Hiawatha Milwaukee	La Crosse-Portage	102.9	80–S–77.1 81–N–76.2	115–S–53.7	*Pioneer Ltd.*
Denver Zephyr Burlington	Galesburg-Aurora	124.5	97–E–77.0	97–E–77.0	*Denver Zephyr*
	Chicago-Galesburg	162.0	127–W–76.5	130–W–74.7	
Twin Cities *"400"* Northwestern	Evanston-Racine	49.9	39–N–76.8		
Zephyr 9902 Burlington	Galesburg-Galva	23.0	18–E–76.6	26–E–53.1	*Ak-Sar-Ben* *Am. Royal*
Interstate Express New York Central	La Porte-So. Bend	26.7	21–E–76.3	29–E–55.2	No. 614
City of Denver Union Pacific	No. Platte-Kearney	95.0	75–E–76.0	71–E–80.3	*City of Denver*
	Julesburg-No. Platte	81.2	65–E–75.0	63–E–77.3	
Green Diamond Illinois Central	Kankakee-Gibson City	54.1	43–S–75.5	46–S–70.6	*The Daylight*
California Zephyr Burlington	Aurora-Galesburg	124.5	99–W–75.4	96–W–77.8	*Denver Zephyr*

* *Afternoon Zephyr* only.

speeds were thought remarkable for a time when a limited train was still defined as one "bearing a distinctive name; operating at an over-all speed of 40 miles per hour or more for distances of over 200 miles." Moreover, they were the forerunners of a fleet of 21 Diesel streamliners which, within another five years, were to provide transportation for the American public on schedules calling for rates in excess of 70–75 miles per hour between stations, with one train actually carded to do better than 80 on two of its runs.

In retrospect, all early Diesels admittedly were cramped inside, compared with standard equipment, and the vibrations of the power plant – and its fumes – often were unpleasantly noticeable aft, even unto the observation it sometimes seemed. Yet the public liked these trains, not only for their speeds and the novelty of riding something new and different, but for what they portended as relaxing influences upon the thinking of railroad managements, long regarded as inexorably allergic against improvements advocated

Representative Fast Railroad Runs Between Metropolitan Centers in the United States and Canada

(Figures after names of trains indicate hours, mileage, and average speed, respectively. Example: the present schedule of Pennsylvania's *Congressional* between New York and Washington in 3.6 hours over a distance of 227 miles is at an average of 63.0 miles per hour.)

Number of Run and Terminals	Railroad	1950	1940	1930	1920	1910	Number of Run
1 New York–Washington	Pennsylvania	*Congressional* 3.6–227–63.0	*Congressional* 3.6–227–63.0	*Congressional* 4.5–226–50.2	*Congressional* 5.1–226–44.4	*Congressional* 5.0–226–45.2	1
2 Boston–New York	New Haven	*Merchants*[1] 4.0–229–57.3	*Yankee Clipper* 4.5–229–50.9	*Yankee Clipper* 4.75–229–48.2	*Merchants* 5.2–229–44.1	*Merchants* 5.0–233–46.6	2
3 Chicago–St. Louis	Illinois Central	*Green Diamond* 5.2–294–56.5	*Green Diamond* 4.9–294–60.0	*Mich. Boulevard* 6.5–294–45.3	*Daylight Spec.* 8.0–294–36.8	*Daylight Spec.* 8.0–293–36.7	3
	Gulf, Mobile & Ohio[2]	*Abraham Lincoln* 5.2–284–54.6	*Abraham Lincoln* 4.9–284–58.0	*Alton Ltd.* 6.5–284–43.7	*Alton Ltd.* 7.75–284–36.7	*Alton Ltd.* 8.0–284–35.5	
	Wabash	*Blue Bird* 5.4–286–52.9	*Blue Bird* 5.2–286–55.0	*Banner Blue* 6.5–286–44.0	*Banner* 7.8–286–36.7	*Banner* 8.0–286–35.8	
4 Montreal–Toronto	Canadian National	*International*[3] 6.25–335–53.6	*Inter-City* 6.5–334–51.3	*Inter-City* 6.0–334–55.6	*International* 7.7–334–43.4	*International* 7.5–334–44.5	4
5 Chicago–St. Paul	Burlington	*Morning Zephyr* 6.25–427–68.3	*Morning Zephyr* 6.25–431–68.9	*North Coast* 9.8–431–44.0	*North Coast* 12.9–431–33.4	*Oriental* 12.3–431–35.0	5
	Milwaukee	*Aft. Hiawatha* 6.25–410–65.6	*Aft. Hiawatha* 6.5–410–63.1	*Olympian* 9.8–410–41.8	*Olympian* 12.4–410–33.1	*St. P.–Minneap. Spec.* 11.7–410–35.0	
	Northwestern	*Twin Cities "400"* 6.25–396–63.4	*The "400"* 6.5–396–60.9	*Victory* 9.8–396–40.4	*North American* 12.8–411–32.1	*St. P.–Minneap. Exp.* 10.8–412–38.2	
6 New York–Buffalo	New York Central	*Ohio State Ltd.* 7.6–436–57.3	*Empire State* 7.75–436–56.3	*Empire State* 8.5–436–51.3	*Empire State* 9.0–439–48.8	*Empire State* 8.75–443–50.6	6
7 New York–Pittsburgh	Pennsylvania	*Broadway* 7.9–439–55.6	*Broadway* 8.0–440–55.0	*Spirit of St. Louis* 9.4–440–46.8	*Broadway* 9.6–441–45.9	*Pennsylvania Spec.* 8.75–439–50.2	7
8 Boston–Washington	New Haven and Pennsylvania	*Senator* 8.25–458–55.6	*Senator* 9.0–458–50.9	*Senator* 9.5–458–48.2	*Colonial* 11.75–458–38.1	*Colonial* 12.7–444–35.7	8
9 Chicago–Pittsburgh	Pennsylvania	*Broadway* 7.9–468–59.2	*Broadway* 7.9–468–59.2	*Liberty* 9.7–468–48.3	*Broadway* 10.3–468–45.5	*Pennsylvania Spec.* 9.1–468–51.4	9
10 San Francisco–Los Angeles	Southern Pacific	*Morning Daylight* 9.75–470–48.2	*Daylight* 9.75–470–48.2	*Daylight* 11.75–471–40.1	*Lark* 14.25–475–33.3	*Shore Line* 13.5–475–35.2	10
11 Cincinnati–Atlanta	Louisville & Nashville	*Southland* 11.5–490–42.6	*Southland* 11.6–489–42.1	*Southland* 12.8–488–38.1	*Southland* 15.0–488–32.5	Number 33 14.0–487–34.8	11
	Southern	*Royal Palm* 12.6–491–38.9	*Royal Palm* 12.5–491–39.3	*Royal Palm* 12.8–491–38.3	*Royal Palm* 17.25–493–28.6	*Florida Spec.* 15.0–494–32.9	
12 Washington–Atlanta	Southern	*Southerner* 12.7–638–50.2	*Crescent* 14.8–638–43.1	*Crescent* 16.25–638–39.3	*N.Y. & New Orleans Ltd.* 20.5–649–31.6	*N.Y. & New Orleans Ltd.* 19.25–649–33.7	12
13 Portland–San Francisco	Southern Pacific	*Shasta Daylight* 15.5–718–46.3	*Cascade* 19.5–725–37.2	*Cascade* 21.2–721–34.0	*Oregonian* 32.8–745–22.7	*Shasta* 27.5–745–27.1	13
14 St. Louis–Dallas	Missouri Pacific	*Texas Eagle* 14.0–711–50.8	*Sunshine Spec.* 16.0–711–44.4	*Sunshine Spec.* 17.9–711–39.7	*Sunshine Spec.* 19.1–707–36.3	Number 3 23.0–708–30.8	
	Missouri–Kansas–Texas	*Texas Spec.* 13.6–689–50.7	*Texas Spec.* 16.0–767–47.9	*Texas Spec.* 17.9–767–42.8	*Texas Spec.* 19.25–767–39.8	*Katy Ltd.* 23.2–767–33.1	14
	Frisco	*Texas Spec.* 13.6–689–50.7	*Texas Spec.* 16.0–689–43.0	*Texas Spec.* 17.8–688–38.6	*Texas Spec.* 19.25–688–35.7	Number 6 22.6–684–30.3	
15 Washington–Chicago	Pennsylvania	*Liberty* 16.0–837–52.3	*Liberty* 16.4–836–51.0	*Liberty* 18.75–836–44.6	*Broadway* 19.75–837–42.3	*Pennsylvania Spec.* 18.25–837–45.8	15
	Balt. & Ohio	*Capitol* 15.4–767–49.8	*Capitol* 15.7–772–49.1	*Capitol* 18.75–786–41.9	*N.Y.–Chicago Ltd.* 20.7–779–37.7	*Chicago Ltd.* 21.3–820–38.5	
16 Montreal–Chicago	Canadian National	*International* 17.5–851–48.6	*International* 17.75–849–47.8	*International* 18.25–848–46.5	*International* 23.3–841–36.1	*International* 23.7–842–35.5	16
17 Cincinnati–New Orleans	Louisville & Nashville	*Humming Bird* 19.1–922–48.2	*Pan-American* 22.1–922–41.7	*Pan-American* 23.75–921–38.8	*New Orleans Ltd.* 28.2–923–32.7	Number 1 26.5–923–34.8	17

			17.5–851–48.8	17.75–849–47.8	18.25–848–46.5	23.3–841–36.1	23.7–842–35.5	
17	Cincinnati–New Orleans	Louisville & Nashville	*Humming Bird* 19.1–922–48.2	*Pan-American* 22.1–922–41.7	*Pan-American* 23.75–921–38.8	*New Orleans Ltd.* 28.2–923–32.7	Number 1 26.5–923–34.8	17
18	Chicago–New Orleans	Illinois Central	*City of New Orleans* 15.9–921–57.9	*Panama* 20.0–921–46.0	*Panama* 21.0–921–43.8	*Panama* 22.75–921–40.5	*New Orleans Spec.* 25.25–921–36.5	18
19	New York–Chicago	New York Central	*20th Century*[4] 15.5–961–62.0	*20th Century* 16.0–961–60.0	*20th Century* 20.0–961–48.0	*20th Century* 20.0–979–48.9	*20th Century* 18.0–983–54.6	19
		Pennsylvania	*Broadway* 16.0–908–56.8	*Broadway* 16.0–908–56.8	*Broadway* 20.0–908–45.4	*Broadway* 20.0–909–45.4	*Pennsylvania Spec.* 18.0–909–30.2	
20	Boston–Chicago	B. & A. and New York Central	*New England States* 18.0–1019–56.6	*New England States* 19.0–1019–53.6	*20th Century* 22.25–1019–45.8	*20th Century* 22.25–1038–46.5	*20th Century* 20.5–1043–50.9	20
21	New York–Jacksonville	Atlantic Coast Line	*Champion* 17.9–1024–57.2	*Champion* 18.25–1021–56.0	*Havana Spec.* 22.5–1021–45.4	*Florida Spec.* 27.0–1021–37.8	*N.Y. & Florida Spec.* 24.8–1018–40.1	21
		Seaboard	*Silver Meteor* 18.4–983–53.4	*Silver Meteor* 18.6–983–52.8	*Southern States Spec.* 25.75–982–38.2	*Seaboard Florida Ltd.* 27.5–982–35.7	*Seaboard Florida Ltd.* 24.8–982–39.6	
22	Denver–Chicago	Union Pacific	*City of Denver* 16.1–1048–65.1	*City of Denver* 15.6–1048–67.2	*Denver Spec.* 24.75–1048–42.4	*Denver Spec.* 28.0–1052–37.6	*Denver Spec.* 27.0–1060–39.3	22
		Burlington	*Denver Zephyr* 16.1–1034–64.2	*Denver Zephyr* 15.6–1034–66.3	*Denver Ltd.* 24.75–1034–41.8	*Denver Ltd.* 28.5–1034–36.3	*Chicago Ltd.* 27.5–1034–37.6	
23	New York–St. Louis	New York Central	*Knickerbocker* 20.75–1157–55.8	*Knickerbocker* 21.3–1158–54.3	*Southwestern* 23.0–1156–50.2	*Southwestern* 26.6–1158–43.5	*Southwestern* 24.0–1175–49.0	23
		Pennsylvania	*Spirit of St. Louis* 19.9–1051–52.8	*Spirit of St. Louis* 20.0–1051–52.6	*Spirit of St. Louis* 23.0–1052–45.7	*St. Louisian* 24.8–1053–42.5	*24-Hour St. Louis* 24.0–1060–44.2	
24	Boston–St. Louis	B. & A. and New York Central	*Southwestern* 24.2–1215–50.2	*Southwestern* 24.3–1216–50.0	*Southwestern* 25.8–1215–47.1	*Southwestern* 29.1–1216–41.8	*N.Y. Central Ltd.* 26.1–1235–47.3	24
25	New Orleans–Los Angeles	Southern Pacific	*Sunset* 46.5–1996–42.9	*Sunset* 53.75–2007–37.3	*Sunset* 56.3–2008–35.6	*Sunset* 62.5–2003–32.5	Number 9 75.6–2003–26.9	25
26	Chicago–Los Angeles	Union Pacific	*City of Los Angeles* 39.75–2299–57.8	*City of Los Angeles* 39.75–2299–57.8	*Los Angeles Ltd.* 61.0–2299–37.7	*Overland* 72.2–2301–31.9	*Los Angeles Ltd.* 72.0–2310–32.1	26
		Santa Fe	*Super Chief* 39.75–2224–55.9	*Super Chief* 39.75–2227–56.0	*Chief* 56.0–2228–39.8	*California Ltd.* 71.5–2231–31.2	*California Ltd.* 72.0–2267–31.5	
		Rock Island	*Golden State* 45.0–2268–50.4	*Golden State* 58.8–2274–38.7	*Golden State* 61.0–2281–37.4	*Golden State* 73.5–2276–31.0	*California Spec.* 72.0–2275–31.6	
27	Chicago–San Francisco	Union Pacific	*City of San Francisco* 39.75–2263–56.9	*City of San Francisco* 39.6–2261–57.1	*Overland* 56.0–2261–40.9	*Overland* 72.0–2264–31.4	*China & Japan Fast Mail* 66.5–2278–34.3	27
28	Portland–Chicago	Union Pacific	*City of Portland* 40.0–2272–56.8	*City of Portland* 39.75–2272–57.2	*Portland Rose* 57.5–2272–39.5	*Oregon–Wash. Ltd.* 72.0–2266–31.5	*Oregon–Wash. Ltd.* 72.0–2291–31.9	28
		Great Northern	*Empire Builder* 44.5–2260–50.8	*Empire Builder* 57.2–2317–40.5	*Empire Builder* 57.25–2245–39.2	*Oriental* 72.0–2243–31.2	*Oriental* 72.0–2294–31.9	
		Northern Pacific	*North Coast* 56.75–2317–40.8	*North Coast* 57.25–2322–40.6	*North Coast* 57.5–2316–40.3	*North Coast* 72.0–2312–32.1	*Northern Pacific Exp.* 72.0–2319–32.4	
29	Seattle–Chicago	Great Northern	*Empire Builder* 45.0–2211–49.1	*Empire Builder* 56.4–2268–40.2	*Empire Builder* 57.25–2196–38.4	*Oriental* 72.0–2206–30.6	*Oriental* 72.0–2256–31.3	29
		Milwaukee	*Olympian Hiawatha* 45.0–2189–48.6	*Olympian* 56.6–2188–38.6	*Olympian* 58.0–2188–37.7	*Olympian* 72.0–2190–30.4		
		Northern Pacific	*North Coast* 55.75–2331–41.8	*North Coast* 57.25–2344–40.9	*North Coast* 58.5–2335–39.9	*North Coast* 73.2–2335–31.9	*Northern Pacific Exp.* 74.25–2342–31.5	
30	Montreal–Vancouver	Canadian National	*Continental Ltd.* 82.5–2930–35.5	*Continental Ltd.* 82.6–2929–35.5				30
		Canadian Pacific	*Dominion* 82.8–2882–34.8	*Dominion* 83.1–2882–34.7	*Imperial*[5] 98.75–2886–29.2	*Imperial* 111.25–2886–25.9	*Pacific Exp.* 112.5–2897–25.8	
	Total times and mileages of fastest trains on each run		**594.85 hours—30,266 miles**	**633.45 hours—30,469 miles**	**739.15 hours—30,384 miles**	**891.25 hours—30,527 miles**	**880.0 hours—30,601 miles**	
	Average speed maintained by thirty fastest trains		**50.9 miles an hour**	**48.10 miles an hour**	**41.11 miles an hour**	**34.25 miles an hour**	**34.77 miles an hour**	

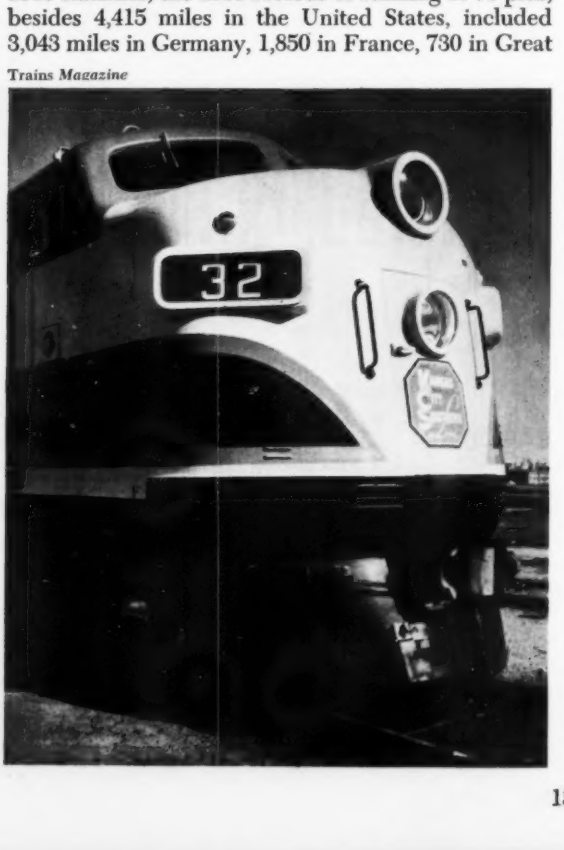
1 When two or more trains of same railroad maintain schedule listed in the table, the name of but one appears. Example: New Haven has two 4-hour trains between Boston and New York, *Merchants* and *Yankee Clipper*.
2 The present, Gulf, Mobile & Ohio was the Chicago & Alton in 1940, 1930, 1920, and 1910.
3 Operated between Montreal and Toronto as Pool Train No. 15 by Canadian National and Canadian Pacific.
4 If schedules differ in opposite directions, the faster is listed in the table. Example: *20th Century* has a schedule of 15.5 hours eastbound Chicago to New York, and 16.0 hours westbound.
5 In 1930, Canadian Pacific also operated *Trans-Canada Ltd.* during the summer season only between Montreal and Vancouver. Its schedule was 86.25 hours for the distance of 2886 miles, or an average speed of 33.5 miles an hour.

from the customer's viewpoint. Designers of the Diesels, on the contrary, catered to public opinion from the beginning, and charmed it by continuing to borrow proven ideas from the experience of those who built aircraft, automobiles, and furniture. They gladly, even affectionately, embraced such features as air conditioning and fluorescent lighting, while most railway managements steadfastly resisted impairment of the *status quo* – until in due course the new ideas paid off in increased passenger revenues.

Stepping up schedules involved, of course, more than merely streamlining trains and making them more comfortable for the riders; more than improving the power plant and contriving better braking to permit added flexibility in acceleration and deceleration; more than handling passengers, mail, and express quicker at intermediate terminals. Safe operation at the contemplated superspeeds demanded expensive alterations along the right of way, such as heavier rails on more substantial ballasting, track realignments, easing of curves and changing their superelevations, reducing grades, longer crossovers and turnouts, and closer attention to the manifold details of bridge and track maintenance. Nevertheless, noteworthy progress both here and abroad was accomplished toward faster averages during 1933–1938.

As previously cited, by 1938 aggregate train mileages booked at 60 miles per hour and over reached a world total of 93,312, of which 48,164 miles were run on American rails. These figures, in themselves indicative of a mounting tempo, included, respectively, 10,169 and 4,415 miles booked to operate at 70 miles an hour or better. Whereas *Cheltenham Flyer* and *Fliegende Hamburger* were isolated entries in the 1933 statistics, the 1938 records of running at 70 plus, besides 4,415 miles in the United States, included 3,043 miles in Germany, 1,850 in France, 730 in Great Britain, and 131 in Italy. Still more striking is the fact that the American and German 1938 figures included for each country more than 1,000 miles scheduled to be run at 75 miles an hour and over, with two runs in each country being at over 80. In 1938, all trains run at 75 and upwards were Diesel powered, the fastest steam train then being *The Hiawatha* of the Milwaukee, averaging 73.9 on its southbound run of 43.1 miles between New Lisbon and Portage, Wis.

Trains *Magazine*



Thus, as events marched onwards in the summer of 1939 towards the commencement of World War II, if one craved a ride on a train at better than 80 miles an hour between two stops, the wish could be gratified either in Hitler's Reich or in the freedom of the Nebraska prairies – either via *Fliegende Kölner*, which ran 109.6 miles from Hannover to Hamm at an average of 82.2, returning at 81.2; or via Union Pacific's eastbound *City of Denver*, averaging 80.3 for 95 miles from North Platte to Kearney, and 81.4 for 62.4 miles from Grand Island to Columbus. If one were content to do less than 80 yet wanted better than 75 miles an hour, there were 15 daily opportunities, plus four available twice-a-week, and still another offered 20 days of each month, viz.:

Nine daily opportunities occurred on Nazi trains, one on the French *État* between Paris and Longueau (78.2 miles at an average of 75.7), three on *City of Denver* (excluding the above-mentioned pair at over 80), and two on Burlington's *Denver Zephyr*, in either direction between Aurora and Galesburg in Illinois (124.5 miles, averages: westbound 77.8, eastbound 71.1). Three twice-a-week chances were provided by Santa Fe's *Super Chief* and *El Capitan* on runs east or west from Dodge City, Kansas; and a fourth by eastbound *Super Chief* from La Junta, Colo., to Dodge City (202.4 miles, average 78.3). The 20-times-a-month offerings were on Union Pacific's *Cities of Portland, San Francisco*, or *Los Angeles*, which then ran on trios of successive days, eastbound North Platte to Grand Island (137.2 miles, average 77.7).

To summarize: 10 years ago, in 1939, there were 25 runs (18 operated daily) of 18 different trains scheduled at 75 miles an hour or over, including 14 runs (7 daily) of 7 different American trains. Ten years later, in October of 1949, there were 34 runs of 21 different trains scheduled at 75 miles an hour and over, as enumerated in the table "Trains Booked to Operate Daily . . ." All these 21 trains now operate daily customarily, by Diesel power on American railroads; and the fastest postwar Europe run up to last summer was that by a French National train, *Number 7*, between Poitiers and Angoulême, 70.2 miles at an average of 63.8 miles an hour.

Sustained accomplishment by trains between their major terminals, figured without deduction for intermediate stoppages, however, is of greater significance to more people than are bursts of speed performed over segments of the route. Eastbound *New England States*, for example, now departs from Chicago each afternoon destined to deliver passengers at Boston 18 hours later, making 1,019 miles at an average of 56.6 miles an hour. Rightfully it should be cause for pride to all concerned that this train is booked to cover the 26.7 miles between La Porte and South Bend, in Indi-

ana, in 19 minutes, thus averaging 84.3 miles per hour which at the present time is the world's fastest start-to-stop booking.

But eastbound *New England States* pauses briefly at La Porte and South Bend only to take on passengers for Toledo and beyond; and hence, from the standpoint of public convenience, the speed the *States* attains between these two Hoosier communities is relatively of little direct consequence even to their inhabitants. Its ultrafast operation over this and other intermediate stretches of its total route, however, does have an indirect bearing on the convenience of people in Chicago who want to get to Boston – for, by the present-day *New England States* that transit can be made in one hour less than by the *States* of 1940, four and a quarter hours less than by the *20th Century* of 1930 or 1920, and two and a half hours less than by the *20th Century* of 1910.

Corresponding comparisons for the period 1910–1950 giving the times, distances, and average speeds maintained on 30 representative fast runs between metropolitan centers in the United States and Canada, runs aggregating a mileage of over 30,000, are given in the table on pages 152 and 153. These tabulations, which bring up to date similar data compiled and published by The Review in 1940 and 1930, include runs ranging from the 227-mile New York–Washington service to that of 2,930 miles between Montreal and Vancouver. The 30 runs used divide into groups according to their mileage as follows: a third vary between 200 and 475; about a third, between 475 and 1,000; five are between 1,000 and 1,200; and six are over 2,000.

A summation of the hours and mileages of the speediest trains on each of the 30 individual runs at the beginning of the 1950's indicates a combined average of 50.9 miles an hour, an advance of 2.8 (6 per cent) and 10.8 (26.5 per cent) miles an hour, respectively, over the 48.1 and 41.1 averages of 1940 and 1930. For 1920 and 1910, the corresponding combined averages were, respectively, 34.25 and 34.77. Corresponding summations for the subdivisions mentioned above show the decline in average maintained speeds following World War I (between 1910 and 1920), except for the longest runs; the rises during each of the two decades spanned by 1920–1940; and the further post-World War II rises in the latter 1940's:

Group	*Number of runs*	*1950*	*1940*	*1930*	*1920*	*1910*
200–475 miles	10	56.7	55.6	47.2	40.5	42.3
475–1,000	9	51.1	46.1	41.8	35.5	36.5
1,000–1,200	5	56.3	55.5	46.1	41.3	45.2
Over 2,000	6	47.6	45.1	37.8	30.5	29.9

It will be observed that the combined net time savings on the 30 runs by the fastest trains of 1950 over those of 1940 totaled 35.4 hours, a net gain of over 5 per cent. On five runs no time-change took place; 21 are now faster, and four have been slowed. Of the 21 runs which have been speeded up, least impressive is a gain of one hour in the Montreal-Vancouver service, one of the few trains listed in the table on page 153 still depending on steam. Should the data for this run be disregarded, on the grounds that it no longer deserves treatment as a "fast" run in comparison with the other 29 runs listed, then the combined averages for the remaining 29 runs would become 53.3 and 50.0 miles an hour, respectively, for 1950 and 1940. On the four runs which have been slowed since 1940, the effect of their time-loss (totaling one and one tenth hours, principally through an extension of a half hour in the eastbound schedule of *City of Denver*) upon the combined average of the 30 runs in 1950, has been to hold it at 51.0 miles an hour instead of permitting it to rise to 51.1.

Although this survey is concerned primarily with railway speeds attained in the United States and Canada, it will be of interest to conclude by giving comparable averages between some European metropolitan centers – as they stood last summer and during the summer of 1939 before the outbreak of World War II, and as they were back in 1930. In the United Kingdom, for example, *Coronation* (London-Edinburgh) and *Coronation Scot* (London-Glasgow), which were maintaining respective averages of 65.5 and 61.7 miles an hour in 1939, have not been as yet rescheduled postwar; but *Flying Scotsman* and *Royal Scot* still depart from London daily at 10.00 A.M. – the hour at which *Royal Scot* has been appointed to leave each morning since 1848! The comparative averages of these two last-named trains, and of two others on higher-speed English runs, are as follows:

London to:	*Miles*	*Train*	*Average miles an hour 1949*	*1939*	*1930*
Edinburgh	393	*Flying Scotsman*	46.8	56.1	47.6
Glasgow	401	*Royal Scot*	45.6	57.3	48.5
Liverpool	193	*Merseyside Express*	49.4	58.2	48.0
Plymouth	226	*Cornish Riviera*	50.2	55.2	55.2

French timetables of 1949 include but two services, from Paris to Lyon or Bordeaux, calling for operating

(*Continued on page 180*)

Jacqueline Briggs from Black Star

The Twentieth Century Mid-Point

Accomplishment in Science and Engineering Looms Large in a Look Backward upon 50 Fabulous Years

By PAUL COHEN

As the earth swings into the orbit that will mark the first year of the sixth decade of the Twentieth Century, A.D., a look backward at the last 50 fabulous years seems in order. The occasion is a routine mathematical occurrence marking the arrival on the calendar of the year 1950. Amid today's frenetic rush of events, however, any excuse to turn for a moment and take stock of the tide of achievement that seems to be overwhelming us appears to be a valid one, and to The Review, whose life has been coincident with this period, the occasion is particularly appropriate. The reference here is primarily to the accomplishments of science and industrial technology. From the vaster issues of history—the advance, if any, in human rights and happiness, in wisdom or world stability—the author shies away without apology.

The first difficulty is to peer beyond the dazzle of the immediate moment, and to assess, on a thumbnail scale, the world of 1900. For the statistically minded, the brief table of data for a few selected topics (page 157), provides some significant comparisons. The changes that have since occurred are impressive enough without seeking an older frame of reference.

For all its gaslight and horseless carriages, the United States of 1900 was already a mature industrial society, containing within itself, in full or embryonic form, most of the features that we today call the modern aspects of our economy. The population of the Continental United States in 1900 was just under 76,000,000, almost exactly half that of today. In their main features, the sanitation practices that mark urban living today were largely in effect, and these, plus control of many of the more important epidemic diseases had resulted in raising the average span of life for white persons to about 50 years. Today the figure for our tougher sex, the women, has reached the Biblical three score and ten.

As for technology, the industrial revolution had already been in operation for more than a century, and even in 1900 it was stretching a point to call such a hoary institution a revolution. True, in all of the United States there were only 8,000 automobiles, no airplanes, and not a single radio set.* There were, however, 1,300,000 telephones and a sufficiently complete telegraph net over the country so that, after the World Series contests started in 1903, nearly the entire American population could cluster around the bulletin boards every fall as, inning by inning, the games slipped into the record books. It was not until 1911 that the total number of patents issued in this country reached the million mark. It stands currently at over 2,400,000.

Representing an average consumption of about three and a half tons per capita per year, the production of coal was about 270,000,000 tons in 1900 and climbing steadily. Our production per capita today is not much larger,† but of course energy consumption has increased much faster than these figures would indicate. Instead of the slightly less than 8,000 trillion British thermal units which the American people used with rather low efficiency in 1900, our consumption today is in the order of 36,000 trillion British thermal units and still going up. Oil consumption has increased enormously (about 28 times since 1900), and hydroelectric power today is at least three times as great as in 1910, when it was already beginning to feel the stimulus of advances in water turbines and in the long-distance electrical transmission of energy. The latter owes its start to a Nineteenth-Century invention, the electric light. By 1920 the practicality of transmitting electric power by high voltage A-C methods had been established for distances up to 200 miles. As the small, isolated steam power plant faded as a major industrial unit, power production began to be dominated by huge central stations, whether steam or hydroelectric.

The incandescent electric lamp can also lay a claim, though rather a thin one, to some of the parental responsibility for the rayon industry. In the days of the carbon filament, manufacturers of cellulose nitrate (celluloid) and of regenerated cellulose (viscose) made filaments for this application. Commercial production of artificial silk (renamed rayon in 1924) started in France in 1891, but for the next 15 years remained a fabric more noted for defects than for virtues. Since then the use of synthetic textiles has grown enormously, overcoming their earlier difficulties so thoroughly that some of them have displaced cotton in many of industries' toughest applications, such as in truck and airplane tires. In 1938, before the rise of nylon, vinyon, and the most modern synthetic fibers, rayon for the first time exceeded wool consumption, and represented slightly less than 10 per cent of the total weight of all textile fibers used that year in this

* Marconi had reported bulletins of the American Cup Races by radio in the fall of 1899, and opened his station at Wellfleet, Cape Cod, on January 19, 1903.

† It was about four and a half tons per capita in 1945.

country. In nylon and its functional, if not chemical, cousins, man has for the first time produced fibers superior in many physical properties to the finest natural fibers.

Changes have occurred also in a field still closer to us than our clothes, namely, in food habits, as Frederic W. Nordsiek, '31, pointed out in The Review‡ for May, 1947. We continue to eat about as much, in calories, as we did in 1900, or to be more accurate, in 1909 when the Department of Agriculture began to keep records on food consumption. But we eat much more of the "sissy" foods, such as milk, oranges, tomatoes, leafy green and yellow vegetables, and sugar. We are eating much less of such foods as potatoes, bread, cereals, and apples. Obviously, the total amount of food consumed today is just about twice what it was in 1900. But the output of the food-manufacturing industry — processed food — has quadrupled since 1899. Advertising, a force not unknown to the Americans of 1900, has played its part in these changes, sometimes along the same lines as medical thinking, sometimes on its own, but the major causes have been technical factors that were in evidence in 1900, though they had not yet begun to operate on a farm or consumer level. Canning was publicized in 1810, refrigerating machinery invented in 1880, and pasteurization known since Louis Pasteur devised the process to prevent deterioration of wines, beers, and milk. The apparatus to process foods to near sterility and to preserve them in that state through the slow and intricate channeling from producer to consumer had to be designed, built, and distributed on a national scale. Until 1921, for example, when about 5,000 units were made, there were virtually no mechanical refrigerators in domestic use. For many perishable foods, high-speed and refrigerated transportation was an essential preliminary to widespread use, and every improvement in fast, flexible transport (the motor truck being the prime example) has added new delicacies to our tables. The airplane has added avocados from Cuba, tropical flowers from Hawaii, and raised talk of such exotic delicacies as mangosteens for breakfast. Queen Victoria offered a small fortune for a mangosteen delivered fresh to her table, and found no takers.

A list of such changes could go on indefinitely. The rise of the gasoline era, as Isaiah Bowman calls this day of the automobile, has so increased the mobility of the general population that a creature known as a suburbanite has sprung up. An associated effect, with wide implications for distribution and real-estate values, is the chronic and apparently incurable traffic jam that is afflicting virtually every large American city, and is spreading to the larger cities of South

(*Continued on page 174*)

‡ "America's Changing Food Pattern," page 401.

Some Significant Changes in the United States During the Twentieth Century

Item	*1900 Amount*	*Present Amount*	*Year*	*Factor of Change**
Population, Continental United States	75,994,575	150,000,000	1949	1.97
Years of Life Expectancy at Birth, White Males	48.23[1]	65.1	1946	1.35
Years of Life Expectancy at Birth, White Females	51.08[1]	70.3	1946	1.37
National Income Produced (millions of dollars)	19,100	160,700	1945	8.42
Number of Gainfully Employed Civilian Workers	29,025,000	59,214,000	1948	2.04
Total Membership in All Unions	791,000	15,600,000	1948	19.7
Total Energy Supplied (trillions of B.T.U.)	7,905	36,030	1945	4.55
Electric Energy Production (millions of watt-hours)	5,969,051[2]	271,254,896	1945	45.5
Coal Production, Bituminous and Anthracite (tons)	269,684,027	632,551,236	1945	2.35
Pig Iron Production (tons)	15,443,951	53,224,213	1945	3.45
Steel Ingots and Castings (total long tons)	10,188,329	71,162,186	1945	7.00
Railroad Passenger Miles (thousands)	16,038,076	91,826,353	1945	5.73
Vehicle Registrations (automobiles, busses, and trucks)	8,000	40,622,264	1948	5,072
Enrollment in Colleges and Universities	237,592	2,338,226	1947	9.86
Membership in Engineering Societies	8,505	190,000	1949	22.3
Employees in Executive Branch of Federal Government	208,000	3,769,646	1948	18.1
Total Federal Expenditures (dollars)	520,860,847	100,404,594,686	1945	1,920
		39,326,072,233	1948	755
Gross United States Public Debt (millions of dollars)	1,263	252,292	1948	200
Per Capita Debt of United States Government (dollars)	16.60	1,721.45	1948	103.6

* Present amount divided by 1900 amount. [1] For 1900–1902 [2] For 1902

Wherever possible, data is taken from *Historical Statistics of the United States* (U.S. Department of Commerce, 1949)

Mineral Depletion and Metal Supply

During the Past Half Century More Minerals Have Been Mined Than in All Prior History, and the Rate of Consumption Is Still Rising Rapidly

By EVAN JUST

MODERN civilization depends on minerals so greatly that it is difficult to imagine what our surroundings would be if minerals in common use were virtually unavailable. Presumably, with our highly organized methods and scientific knowledge, we would live more comfortably than aborigines, but there can be no doubt that the material living standards which we have come to regard as essential depend very heavily on minerals. In an imaginary nonmineral world we would at least have to dispense with such commonly used conveniences as railways, automobiles, telephones, electric light and power, furnaces, china and glass, and large buildings.

These conjectures become of more than academic interest when we look at the problem of metal and mineral supply in a quantitative way. On the consumption side, it may be startling to realize that, for the world's white population, the per capita requirements for minerals have multiplied 30 times in 30 years, or that more minerals have been mined in the last 40 years than in all prior history. On the supply side, we have the estimates of the Department of the Interior that our known and inferred reserves of several commercially important minerals are definitely limited to the following: In terms of average annual production for the 1935–1944 decade, petroleum reserves should last for 40 years; copper, 25 years; lead, 15 years; zinc, 24 years; and direct-shipping iron ore, 15 years. To this I would add that a quantitative analysis of the way we are depleting or polluting a precious resource, good underground water, is in itself some cause for concern. The Californians seem to be learning the value of good water supplies!

The Strategic Materials Division of Economic Cooperation Administration was set up because Congress was so deeply concerned over reserve depletion that it insisted there must be some return for Marshall-Plan aid, in the way of availabilities, if not of actual deliveries, of "materials in which the United States is deficient or potentially deficient." Congress is greatly interested in protecting the future resource position of the United States.

Do these ominous statements mean that civilization shortly will be forced to alter its ways profoundly? Must we, in a few generations return to horse-drawn vehicles, candlelight, and handicraft industry? Must we relinquish the privilege of slaughtering other people by the millions and gratify our blood lust only through individual combat? Parenthetically when I reflect on air warfare, atomic bombs, or even what insistent nuisances the telephone in my office and the radio at home have become, I could stand for some of these handicaps with cheerful resignation!

My answer to the question posed is that, even assuming that the bulk of the earth's population adopts the mode of life common in North America and Western Europe, thus skyrocketing the world's mineral requirements, we shall suffer no serious inconveniences or interferences with material progress for lack of mineral materials. We shall be able to continue devising even more fiendish ways of destroying each other.

This conclusion is supported by the inefficient manner in which our mineral resources have been used in the past. In the first place, we tolerate wastes that, if curbed, could contribute immensely to extend our mineral supplies. Having no conscience in regard to posterity that prevents our using tin for dog-food cans, sinking battleships for target practice, or allowing immense soil and fertilizer values to drain into the ocean, we at least know that, at a price, these wastes can be avoided and even a good deal of material now wasted will be reclaimed. I would like to point out here, however, that important percentages of even so-called indestructible metals, like gold, silver, lead, and copper, are irrevocably lost in their first services to society. In other words, we cannot relax under the illusion that eventually we will fill our metal needs by turning over a great scrap pile.

We are lucky enough, furthermore, to have substitutes with plenteous reserves behind them for most, if not all, of the uses of our scarcer minerals. For our present needs of iron and steel we have great supplies of lower-grade iron ore which can continue to fill requirements for many generations and, thanks to the metallurgists, at surprisingly small additions to cost. The rather limited deposits of high quality ferroalloy minerals can be greatly extended when the metallurgists become less selective about quality and condescend, at a price of course, to use lower-grade supplies. In its most essential use, electrical conduction, copper already has a formidable competitor in aluminum. If copper should become entirely unavailable to the electrical industry, which of course will not happen, we should simply have to use somewhat larger devices to obtain similar results. Aluminum is also giving zinc producers considerable food for thought, being already a competitor with galva-

nized roofing, siding, utensils, and zinc die castings. Considering that it is made from high-grade bauxite, one might say that aluminum itself does not exist in boundless reserves; but between the probabilities that much undiscovered bauxite exists and that metallurgists will find ways to use lower-grade aluminous materials, it is hard to foresee a dearth of aluminum.

One of the most tenacious applications of the metals is lead for storage batteries, as we have no effective substitute. True, there is the nickel-steel alkaline battery, but should it be asked to take over the load now being carried by lead batteries, we would run into the fact that nickel is much scarcer than lead. Pending the day when an effective substitute for lead in storage batteries is developed, it appears that here is at least one important instance when a dearth of the material would force us to change our ways. Are the obviously short reserves of lead, then, an ominous sign? The answer is "No." In the first place, lead has reasonable substitutes in the construction, plumbing, chemical, paint, cable covering, and weighting fields, so that the apparent supplies could be extended very far, if devoted to storage batteries alone. Besides, for a sufficient price incentive, the lead in storage batteries is almost 100 per cent reclaimable. Finally, a substantial increase in the price of lead, still well within the means of storage-battery users, would bring out new supplies from all over the world. Therefore, even in this unusual case of a monopolistic hold on a market and an apparently short supply, there appears to be no cause for consumers to worry about the future. Because of its limited reserves, durability, and wide usefulness, lead may be an appropriate item for hoarders who fear currency depreciation; but the needs for its more essential uses will be met, and at prices which although possibly high in comparison to the past, will still be well within the reach of the ordinary consumer.

Another apparently essential mineral use is that for manganese as a clean-up agent for steel. This country uses 14 pounds of manganese for every ton of steel produced, and Europe uses more. I have so much observed the ability of metallurgists to find answers when needed, that I have complete faith that we shall never lack good steel, even if manganese becomes relatively scarce.

Indefatigable metallurgists are constantly working—and achieving results—toward bringing new metals within the economic sphere. Some of these metals are backed up by very abundant reserves. Aluminum is, of course, a hackneyed example, and magnesium is well on its way. It is worth noting here that the last-named metal is produced most cheaply from an inexhaustible source, sea water. Now also, we have titanium showing such promise that prudent industrialists are spending millions of dollars to hasten its economic applications.

The development of new metals presents challenging tasks to an army of metallurgists who are delving into ways of producing them more cheaply, alloying them more usefully, and equipping industry to applying them more effectively. In modern society no one man has more than a small segment of this extremely ramified job, and the blind experimental alleys vastly outnumber the roads by which progress is achieved. Nevertheless, to participate in bringing new materials to the workshops (and thus enabling industry to make new offerings of better living to more people) is certainly an inspiring basis for a career. I wish only that the benefits of these accomplishments could be more widely utilized. In too large measure, it seems to me, we become the slaves, rather than the beneficiaries, of the system we are creating, or waste the advantages placed at our disposal in mere time-killing amusement, to say nothing of our aptitude for using the accomplishments of science and engineering for destructive purposes.

The plastic and glass industries are also making important contributions toward offering substitutes for many applications of the metals. These items are already in such common use that it is superfluous to recite specific examples.

Thus, we can look to the metallurgists and other technologists to cushion our economy against shortages by developing substitute materials that will enable us to use dwindling supplies of the metals, if they occur, for the more essential uses. If there is any fundamental cause for concern over resources, it lies in pollution of the atmosphere, in water supplies, or in the depletion of soil and phosphates. These items may become limiting factors to human growth in due time. However, more effective conservation of these resources can greatly postpone the day of reckoning.

Then, there is the role the prospector and miner can play in discovering new mineral reserves. I use these terms rather than "geologist" and "mining engineer" because I think we are too inclined to emphasize technically trained personnel in this activity, without realizing that a large share of the accomplishment, probably the major part, is due to people whose equipment is essentially common sense, experience, or managerial skill. Most informed people believe that there must be more economic minerals undiscovered than discovered. Nobody knows how far the new type of geologist, heavily fortified with physics and chemistry, may push extrapolative geology, or how effectively geophysical and geochemical prospecting may disclose concealed deposits. On the other hand, considering the depths to which mining is pushed and the extent to which we continue to rework and exploit old districts, it would be rash to predict when well-mineralized areas will be finally exhausted,

We now come to a factor in this picture which, although simple and self-evident, is usually overlooked in discussions of depletion and its effect on human progress. This factor is price, and its impact on activity. Often there seems to be too much consideration of technological accomplishment without weighing the strong control exercised by prices. We should have much fewer chances to apply new machines and methods in industry except for the insistence of workmen on higher and higher prices for their labor. Indeed, I fear that the increased output per worker which has been achieved during and since World War II may result in serious social problems before very long.

(*Continued on page 170*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Assistant Treasurer for Alumni Association

UNANIMOUSLY and enthusiastically the Executive Committee of the Alumni Association, at its meeting on November 28, voted the appointment of Madeline R. McCormick to the new post of assistant treasurer of the Association. This action requires certain changes in the bylaws of the Alumni Association as stated in the report of the Council meeting presented in this issue of The Review. When these changes are voted by the Alumni Council at its January meeting, the new post will be effective and retroactive as of January 1, 1950.

Educated in the public schools of Portland, Maine, Miss McCormick was first associated with the Institute in 1919 in the office of the Educational Endowment Fund which was then under the direction of the late Merton L. Emerson, '04. A year later, she joined the staff of the Alumni Association and began her recordings of the financial accounts of the Association and The Technology Review. Walter Humphreys, '97, Secretary of the alumni organization at that time, was the first of many officers of the Alumni Association with whom she worked.

Celebrating 30 years of loyal and capable service to the Association, Miss McCormick's continuous presence has been a helpful guide to the many who have held office, and particularly to the individuals who have been secretary and treasurer. On this roster are: Orville B. Denison, '11, Secretary-Treasurer who succeeded Mr. Humphreys; President Killian and Ralph T. Jope, '28, who acted as treasurer in 1928 and 1938, respectively; John O. Holden, '24, Secretary in 1929; Laurence P. Geer, '15, Secretary in 1930; the late Professor Charles E. Locke, '96, Secretary from 1931 until his death in 1948; and the present Secretary and Treasurer, Donald P. Severance, '38.

For several years, in addition to her accounting duties, Miss McCormick has been in charge of the details of operation and the personnel of the Alumni Office. A calligrapher of distinction, and a person of sound judgment based on experience, the Alumni Association welcomes her as the first appointee to this new post.

Changes in Bylaws

MEMBERS and guests numbering 119 persons attended the second meeting of the season, and the 271st meeting of the Alumni Council, which was held in the Graduate House on November 28, 1949. C. Adrian Sawyer, Jr., '02, President of the Alumni Association, presided. During the business portion of the meeting it was reported that 10 members of the Faculty and Alumni Council had visited 13 M.I.T. Clubs from Brunswick, Maine, to Havana, and as far west as Kansas City, Mo. Henry B. Kane, '24, Director of the Alumni Fund, announced that "as of November 25, some 8,300 Alumni had contributed a total of almost $126,000 to the current fund. In numbers this is somewhat less than last year at the same time; in amount, the same."

Parke D. Appel, '22, chairman of the Committee on Assemblies, reported that the Midwinter Meeting for the Alumni in Metropolitan Boston would be held in Walker Memorial on Saturday, February 4, 1950.

The Executive Committee recommended to the Alumni Council two changes in the Alumni Association bylaws, as follows:

Insert a new Article IX to read:

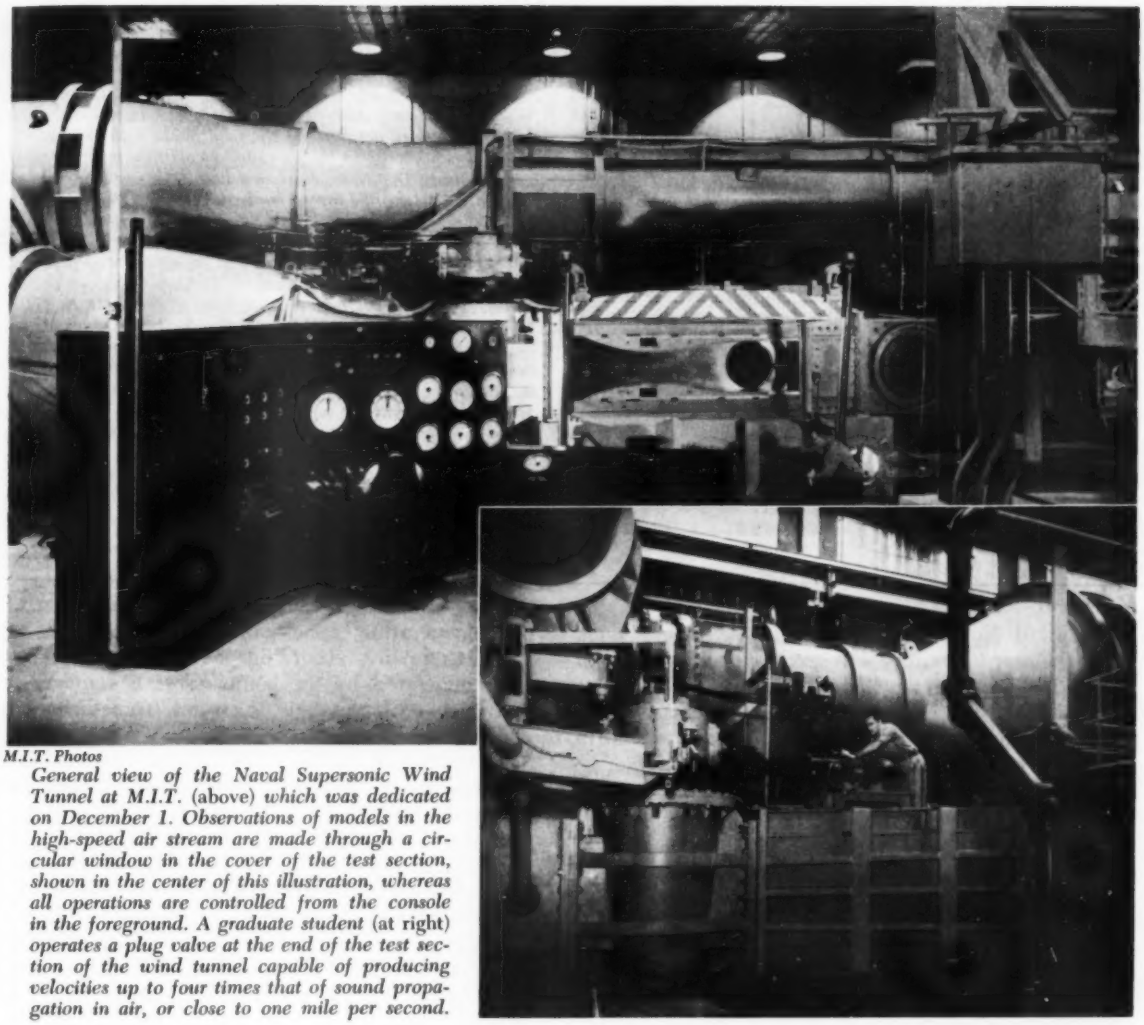
In addition to the officers of the Association provided for in Article III, Section 1, of the Constitution, the Executive Committee may appoint an Assistant Secretary and an Assistant Treasurer, who shall not be members of the Executive Committee. These additional officers of the Association shall serve subject to the pleasure of the Executive Committee and perform such administrative duties as may be prescribed from time to time. Eligibility for appointments thereto shall not be restricted to the membership of the Association.

Renumber as Article X the present Article IX which reads:

The Bylaws may be amended at any time by a majority vote of the full membership of the Council, provided thirty days' notice of such amendment has been given through publication in *The Review* or by mail to the full membership of the Council.

This recommendation for changes in the bylaws could not be voted on at the November Council meeting, and since there will be no December meeting, because of the Christmas holidays, they will be voted on at the January, 1950, meeting of the Alumni Council.

Malcolm G. Kispert, 2–44, Administrative Assistant to President Killian, presented a résumé of recent developments at the Institute. He announced that a student convocation would be held in the Rockwell Athletic Cage on December 5 at which President Killian would acquaint the student body with the Institute's Development Program, Nathaniel McL. Sage, '13, Placement Officer at M.I.T., would speak on student placement, and Vannevar Bush, '16, President of the Carnegie Institution of Washington, would address the students on "The Essence of Security," which appears on page 147 of this issue. Mr. Kispert announced plans for the dedication of the supersonic wind tunnel at M.I.T. He also reported that Norman B. Champ, '50, had been named student chairman for Open House activities to be held next spring. Mr. Kane was named chairman of the Staff Advisory Committee for Open House.



M.I.T. Photos

General view of the Naval Supersonic Wind Tunnel at M.I.T. (above) *which was dedicated on December 1. Observations of models in the high-speed air stream are made through a circular window in the cover of the test section, shown in the center of this illustration, whereas all operations are controlled from the console in the foreground. A graduate student* (at right) *operates a plug valve at the end of the test section of the wind tunnel capable of producing velocities up to four times that of sound propagation in air, or close to one mile per second.*

Harold L. Hazen, '24, Head of the Department of Electrical Engineering, then introduced the speaker of the evening, Professor Harold E. Edgerton, '27, of the same Department, who discussed and demonstrated the operation and uses of flashlight photography and stroboscopic light. The demonstration included the stopping of bullets in flight and the photographing of the various stages of the collapse of balloons, using the Land camera which provides prints within a minute after exposure. By means of slides, Professor Edgerton showed examples of the use of flash photography in sports, nature, the dance, projectiles in flight, and in the recording of such events as the rodeo and circus.

Supersonic Wind Tunnel Dedicated

THE largest wind tunnel at any university for research on problems of high-speed flight was dedicated on December 1, at ceremonies marking completion of the Naval Supersonic Laboratory at M.I.T. The tunnel, constructed under the auspices of the Navy Bureau of Ordnance, is designed to provide speeds ranging from 1.2 to 4 times that of sound — up to 3,000 miles per hour; and during the dedication it was successfully operated at a speed twice that of sound.

Speakers at the dedication program included: Rear Admiral Albert Noble, '23, Chief of the Navy Bureau of Ordnance; James R. Killian, Jr., '26, President of the Institute; Jerome C. Hunsaker, '12, Head of the Department of Aeronautical Engineering; Edwin G. Schneider, Director of M.I.T.'s Project Meteor; and Professor John R. Markham, '18, Director of the Laboratory. Hugh L. Dryden, Director of Research, National Advisory Committee for Aeronautics, was the principal speaker at a luncheon in the Graduate House following the opening ceremonies. Guests at both events included high officials of the Navy, Air Force, Army, aircraft industry, and several educational institutions.

The Naval Supersonic Laboratory, including building, wind tunnel, and associated instruments, represents a capital investment of $2,600,000. It marks a substantial increase in the laboratory facilities of the Institute, Dr. Killian reported, and will be devoted to both fundamental research and education.

M.I.T. Photo

One of the Institute's newest and finest buildings, the Charles Hayden Memorial Library, is being completed in progressive steps. In August, the Departments of English and History, Economics and Social Science, and Business and Engineering Administration moved into a wing expressly designed to house those educational activities in the field of the humanities.

The second stage in the completion of the library occurred on November 18, when, as shown here, the first books of the English and History Library were moved from Walker Memorial to the first reading room to be completed in the new Hayden Library.

Taking part in the simple, informal opening of the new reading room are: Professor Howard R. Bartlett, Head of the Department of English and History (seated); *Robert E. Booth, Associate Librarian, watching the books being stacked; and Vernon D. Tate, Director of Libraries, in conversation with Professor Bartlett. Transfer of approximately 16,000 books was made during the week end, and the new reading room was opened for student use on November 21. Already it has proved to be a popular reading room for recreation and study by M.I.T. students.*

The remaining portions of the library are still under construction, but are expected to be completed during the late winter. The library will be formally dedicated next spring.

Admiral Noble expressed the Navy's confidence that the new laboratory will serve science as a tool to extend the frontiers of human knowledge, and that it "will inspire future generations of students to more intensive study and assure our country leadership in the field of aeroballistics."

"The tunnel," he said, "represents the most advanced design in our present thinking. It is one unit in a great nationwide complex of laboratories and plants engaged in devising and in making the weapons with which the Army, the Navy, and the Air Force will defend our country."

Professor Hunsaker reported that the Naval Supersonic Laboratory will be used for testing scale models of supersonic missiles and components, and for research to obtain basic aeroballistic information. Results of the research completed in this wind tunnel should make possible improvements in high-speed missiles and aircraft of both piloted and automatically guided types. An extensive training program for advanced students at the Institute will be undertaken in conjunction with the laboratory's research.

The test section of the new wind tunnel, where models are studied in the high-speed air stream created by the machine, measures three square feet (18 by 24 inches). By changing the density of the air passing through the test section, conditions of guided missile and airplane flight at high altitudes can be duplicated. The wind tunnel is capable of sustained high-speed operation and is therefore suitable for the study of problems which require equilibrium conditions, Professor Markham pointed out in a brief description of the tunnel and its auxiliary control mechanisms.

The wind tunnel is a huge closed steel channel, through which very dry air is circulated by two large centrifugal compressors driven by electric motors of 10,000 total horsepower. The four-stage compressors have been especially adapted for this application to a supersonic wind tunnel. The electric power required to operate the wind tunnel represents a large fraction of the generating capacity of the Cambridge Electric Light Company, according to Professor Markham. Heat generated by the compressors is removed by two large coolers which use water from the nearby Charles River as the cooling medium. Approximately 3,000 gallons of water per minute are divested from and returned to the river to cool the various machines within the laboratory.

Supersonic speeds are achieved by shaping the wind-tunnel walls in the vicinity of the test section in a certain specified manner, and special nozzles having the proper contours are required. Different nozzles are used for different speeds of operation. Air temperatures within the test section of the wind tunnel are quite low. At speeds twice that of sound, the temperature is —140 degrees F.; at speeds four times that of sound, —335 degrees F.

Instrumentation available for use with the wind tunnel includes a balance to measure the air reaction on the models and an optical system to show visually the shock waves and flow patterns which surround models in the supersonic air stream.

The wind tunnel and laboratory are under the administration of the M.I.T. Department of Aeronautical Engineering headed by Professor Hunsaker. The design of the wind tunnel, the wind-tunnel balance system, and other items of instrumentation were under the direction of Professor Markham. The Jackson and Moreland Company, consulting engineers of Boston, had charge of the execution of the project.

Design of the wind tunnel was undertaken in December, 1946, and actual procurement of equipment was initiated in the spring of 1947. Construction of the buildings started with the ground breaking by Vice-Admiral George F. Hussey, Jr., then Chief of the Bureau of Ordnance, on M.I.T. Alumni Day, June 14, 1947. Personnel of the laboratory occupied the building in June, 1948. Installation of machinery, equipment, and instrumentation has required the intervening time.

(*Continued on page 164*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

One of the many good qualities of copper is its ability to withstand a great deal of cold working without injury. Nevertheless, rolling, drawing, stamping and similar operations do increase the hardness of the metal. If enough of this cold work is done, it becomes necessary to anneal it, that is, heat it to the proper temperature to relieve the internal stresses and permit the metal to become ductile again, ready for additional forming operations.

Annealing is expensive, because it requires accurately controlled heat and skilled labor. For that reason it is a matter of concern to manufacturers, and Revere often is asked if it is possible to eliminate or at least reduce the number of anneals. Frequently this can be done. Take the case of a coffee pot. No less than five anneals seemed necessary in order to produce this quality product. Costs were high; could they be reduced? The customer's metallurgist and the Revere Technical Advisory Service studied this problem in detail, attacking the matter together. When they arrived at what seemed to be a promising solution (on paper) it was proved out by exhaustive tests. It was found that by using Revere copper strip in a certain temper, four anneals could be eliminated. Now, after drawing to 7¾ inches deep, the copper body is annealed once and for all, then spun into its final graceful shape. Based on current production, the saving amounts to over $10,000 a year. There are additional savings due to simplified handling in the factory. The reduction in the number of anneals also seems to have a favorable influence on the economy of the finishing operations, including tin plating inside, nickel and then chromium outside.

To make such a deep draw while holding rejects to a minimum requires skill on the part of the customer, plus careful fulfillment of the metal specifications by Revere. This is said in no prideful spirit. There are a great many skillful manufacturers in all lines, and many careful, conscientious suppliers of everything from metals to plastics, textiles to lumber, chemicals to paper. The whole point of this particular story of the saving of $10,000 a year poured out of a coffee pot is that it was accomplished by the most thorough kind of collaboration between the maker of the pot and the supplier of the metal. It was that joint effort that made the saving possible.

Perhaps you do not make coffee pots. Maybe you do not buy copper, brass, bronze, nickel silver, cupronickel, aluminum, or any other Revere Metals. No matter. It may be that if you will take your suppliers into your confidence in the common cause of cost reduction you too will be able to effect savings and improve your product, just as happened in this case.

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(*Continued from page 162*)

Dean M. Fuller: 1893–1949

DEAN M. FULLER, Associate Professor of English at the Institute, died on November 23, 1949. He had been at M.I.T. for two decades.

A native of Barre, N.Y., where he was born on November 20, 1893, Professor Fuller served overseas for a year and one-half during World War I. He was graduated from Hamilton College in 1920 and immediately joined the instructing staff at the Institute. He was promoted to the rank of assistant professor in 1928 and became an associate professor in 1938.

Professor Fuller was widely known among the Institute's students for his interest in debating. He had served for many years as director of dramatics and organized the Dramashop, an undergraduate club. He was a leader in the Drama Club of the Faculty and for several years gave an undergraduate course in dramatics for second-year students.

Nelson Award to Dr. Compton

PRESENTED annually to that citizen of greater Boston who has contributed most in the field of public service, Karl T. Compton, chairman of the M.I.T. Corporation, was the recipient of the Colonel Thacher Nelson Award of the Advertising Club of Boston for the year 1948–1949. The medal was awarded to Dr. Compton in recognition of his long and distinguished career as physicist, educator, and humanitarian, during which time he has served his community and his country "in war and in peace – applying his great talents with selfless devotion in the service of his fellow-man."

The medal was accepted for Dr. Compton by George R. Harrison, Dean of Science at the Institute, at a luncheon at the Hotel Statler on November 15, at which James T. Chirurg, '27, was chairman of the day. The award was made to Dr. Compton last spring, when Carlton M. Strong of the Rumford Press was president of the Advertising Club of Boston. Presentation of the award was delayed because of Dr. Compton's frequent absence from Boston while serving as chairman of the Research and Development Board of the National Military Establishment.

Progress in Automotive Research

TWO new developments in automotive engineering at the Institute are expected to help achieve more efficient gasoline engines. Fundamental research on how engines grow, in the M.I.T. Sloan Laboratories for Aircraft and Automotive Engines, may make it possible to obtain facts about large engines from studies of very small ones, as mentioned in greater detail on page 142. In addition, a development of the Institute's Department of Aeronautical Engineering, of a new engine indicator capable of very accurate and sensitive measurements on pressures inside an operating engine, is expected to be of great help in efforts to improve engine performance.

Under the general direction of Professor C. Fayette Taylor, '29, of the Department of Mechanical Engineering at M.I.T., Sloan Laboratory personnel are exploring the effects of size changes in one-cylinder engines, seeking to establish the "laws of similitude" which may be applicable. The program promises to enable designers to predict with precision the changes in performance of an engine as its size is changed. It will thus provide a quantitative basis for choosing designs for greatest fuel economy, lightest weight, or minimum size.

A complementary development at the Institute, President Killian reported on November 29, is that of the improved high-performance engine indicator perfected by Professor Charles S. Draper, '26, of the Department of Aeronautical Engineering, and Yao Tzu Li, '38, a research associate in the same Department.

Although the new instrument applies commonly used strain-gauge principles for measuring pressures inside an engine, it largely overcomes the defects of previous devices. This is accomplished by the use of a curved, instead of flat, pressure-recording drum, and by refinements in the application and instrumentation of the strain gauge itself.

According to Professor Draper, the new instrument developed at M.I.T. is accurate to within 1 per cent over a wide range of temperatures, can be used to measure large variations of cylinder pressure, and yet is sensitive to very sudden pressure changes. Thus it makes possible detailed studies of the rapid vibrations and oscillations of pressure within an engine. Tests of the new instrument indicate that greatly improved performance can be expected.

Both of these developments serve to underscore the importance to industry of the fundamental research performed in educational institutions. They emphasize the "necessity of maintaining American leadership in technological education and research," President Killian declared.

Unity in Science

THE fourth annual Arthur Dehon Little Memorial Lecture at the Institute was given in Walker Memorial on the evening of November 22, 1949, by Detlev W. Bronk, President of Johns Hopkins University, whose topic was "The Unity of the Sciences."

The Arthur Dehon Little Memorial Lectureship was established by Arthur D. Little, Inc., in memory of its founder, and was inaugurated in 1946 with a distinguished lecture by Sir Edward V. Appleton. Other speakers have been J. Robert Oppenheimer, Director of the Institute for Advanced Study, and Robert E. Wilson, '16, chairman of the Board, Standard Oil Company of Indiana.

One of the dynamic figures in American science and education today, Dr. Bronk is a graduate of Swarthmore College and holds the Ph.D. degree in physics from the University of Michigan. Following various teaching appointments and a year of study in England in 1928, Dr. Bronk organized and led an effective group of investigators studying electrical and chemical mechanisms of the nervous system. Until 1948 he

(*Continued on page 166*)

FHA APPROVED

Partial view of Meadowbrook Apartments, Indianapolis, Indiana. Owners: Meadowbrook Sponsors. Architects and Engineers: Allen and Kelley. General Contractor: Mars Engineering, Inc. Heating and Plumbing: Freyn Brothers, Inc. Electrical Contractor: Hatfield Electric Co. All of Indianapolis, Indiana.

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THE INSTITUTE GAZETTE

(Continued from page 164)

was director of the Eldridge Reeves Johnson Foundation for Medical Physics and of the Institute of Neurology, both at the University of Pennsylvania.

During World War II, Dr. Bronk made a distinguished contribution as co-ordinator of research in the Air Surgeon's office, and in work on problems in the fields of oxygen and vision. Since then, as a member of the United States National Commission for the United Nations Educational, Scientific and Cultural Organization (UNESCO), he has concerned himself with international scientific and cultural problems.

Calling for a greater appreciation of "the motives and methods of science," Dr. Bronk told his audience that the success of industrial democracy depends on developing "a closer unity between the sciences and between those called natural and those called social."

He said that a discussion of the social implications inherent in the development of science is particularly timely because of the recent rapid expansion of scientific activities. Present-day culture, Dr. Bronk pointed out, is increasingly dependent upon the products of science and technology, and scientists are thus becoming "essential to our social order." This greater relevance of science to modern society tends to make scientists focus their attention on quick answers to practical questions, a fact which leads to a high degree of specialization.

Dr. Bronk added, however, that the goal of true science is more than quick answers to practical questions. Quantities of data and many individual solutions must be correlated for the development of broad new concepts.

"Science can seldom be developed by scientists who do not have specialized competence," continued Dr. Bronk, "but more than this is needed for the development of science." He stated that we need men able to "comprehend the broad relevance of detailed facts and knowledge and their human implications."

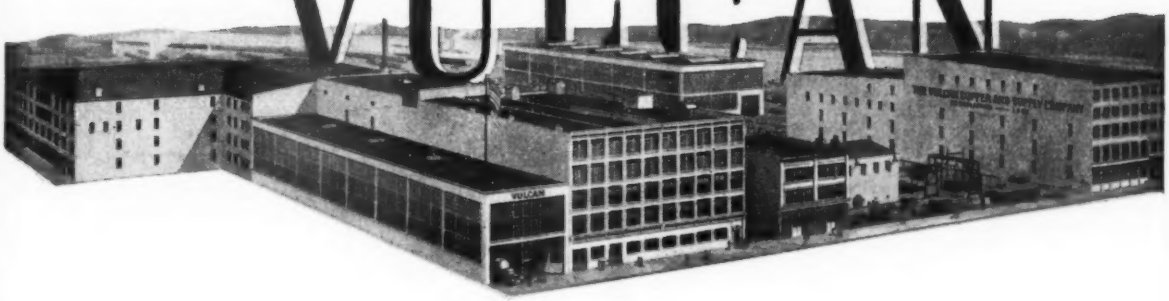
Three compelling motives of modern scientists were listed by Dr. Bronk: the primary one is curiosity, followed closely by the desire to understand and correlate observations resulting from curiosity and by the desire to create something with an ultimate social value. He believes that the cultivation of these "is the surest guarantee of scientific progress."

Dr. Bronk said that the unity of sciences and humanities required for the achievement of future objectives is to be found "in the common search for understanding, in the satisfaction of intellectual inquiry and expression, and in the enrichment of human life."

Dr. Bronk pointed out that the role of the scientist's creative imagination is to form facts and observations into knowledge which lays the foundation for further discoveries. "To bring order out of chaos and attain understanding is one of the great satisfactions for which a scientists will gladly spend his life," he said.

(Continued on page 171)

VULCAN



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Ethyl alcohol — beverage, neutral spirits
Isopropanol Allyl alcohol Butanol

ALDEHYDES
Acetaldehyde Butyraldehyde Furfural

CHLORINATED HYDROCARBONS Chloroethane Chlorobenzenes Chlorotoluenes

ACIDS Formic acid
Acetic acid — from wood distillation
Acetic acid — from process residues and solvent recovery
Acetic anhydride Propionic acid
Butyric acid Stearic acid

GLYCOLS Ethylene glycol
Butylene glycol

KETONES
Acetone Methyl ethyl ketone

ESTERS Methyl acetate Ethyl acetate
Butyl acetate Vinyl acetate Dibutyl phthalate

HYDROCARBONS Butadiene Heptane
Benzene Toluene Styrene Diphenyl

PHENOLS Phenol Naphthol

ETHERS Ethyl ether Isopropyl ether

MISCELLANEOUS Citronellal Geraniol

DDT Essential oils

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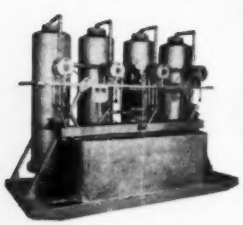

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ESSENCE OF SECURITY

(*Continued from page 148*)

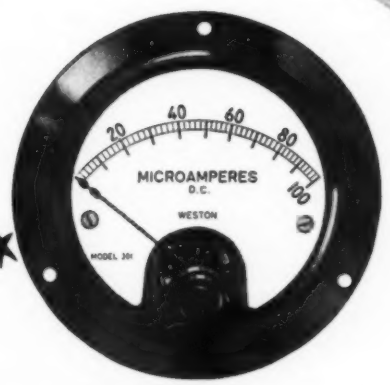
tegral whatever. You will read the newspapers and the current magazines — for relaxation. When you graduate, with the M.I.T. accolade, you will seek out a post that pays a salary and affords the maximum of security, where promotion is sure and slow, and where no one ever got fired who didn't criticize the management unduly. I am not talking to the small fraction who will thus dodge the issue.

I am talking to those who will be men of influence, now and from here out, who have a feeling for the game, and a will to live something besides the life of the oyster. I speak to those who are neither terrified by life, nor lured into wishful thinking regarding a millennium. There are many such among you, as the history of this institution has proved, who would grapple with a tough world, and learn the subtle arts of doing so well. There are many among you who are men of influence today, and who are preparing to be men of great influence tomorrow among your fellows, because of your grasp, your courage, your mental power, and your integrity.

There is an unfortunate tendency in this country to separate the great and small issues; to take the point of view that the large ones are determined in Congress and the Executive Establishment and that they are no direct concern of the individual citizen, pursuing his ordinary affairs within close horizons. Nothing could be further from the truth. The characteristics of the Federal government, the dignity or the lack of it with which we conduct our affairs, internally and in the complex relations between nations, the selflessness, or its opposite, of our governors throughout our far-flung government machine, are but the reflection of the character of the people. As the people think, as they demand effectiveness or tolerate demagoguery, so will our status as a nation evolve. The smallest act of a citizen, influencing his friends and neighbors toward sanity and far-reaching wisdom, multiplied a million times throughout the breadth of this land, can determine that the country as a whole will rise in its dignity and strength to live in prosperity and peace, and not succumb in a welter of petty selfishness and confusion. This is the essence of security.

You men, with the enormous privilege of higher training, in an institution of world renown, and thousands like you throughout this country, you men of influence in the coming generation, will determine where we come out. You will specify, you men who accept the challenge of life, whether we make of this free country of ours a country that grows in freedom and strength, and whether in that strength it will lead the world out of a morass. No one of you will determine it all, or even a great part of it, for the world is large and complex and the efforts of no single man reach far unless he be singularly favored by chance and endowment. But each of you who wishes will shift the trends a bit, and is shifting them now; and together, you of youth who inherit the world, you will determine the outcome. I shall probably not be around to witness the full result, but I wish you luck.

Trustworthy



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MINERALS AND METALS

(*Continued from page 159*)

The prices of the products we produce put definite ceilings on industry's chances to mine lower-grade reserves, take exploratory risks, try out new machines or methods, or finance research. However, it must be admitted that human behavior is illogical enough that we make our greatest progress when under pressure rather than when we are enjoying the most financial elbow room.

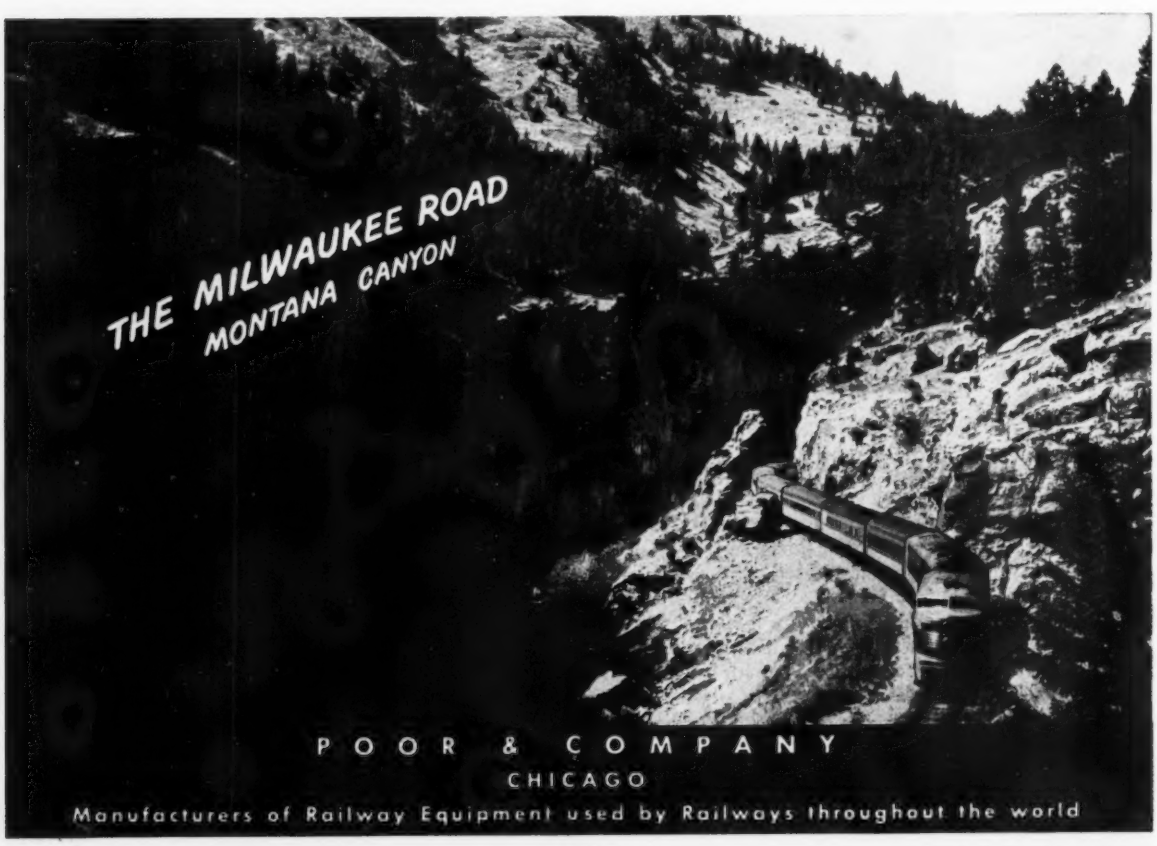
The fluctuations characteristic of price also have a profound effect on depletion and technical progress. Many experiments, whether exploratory, operative, or laboratory research, are foregone because of the fears of businessmen over price declines. Much ore is left in the ground because of selective extraction in periods of low profit margins. Indeed, if there is any justification for cartelization or state regulation of prices, it is because stable prices should encourage orderly extraction, steady mechanization, and research programs, thus promoting resource conservation. This, however, is a tool which can be overexercised, as too much protection can destroy the drive inherent in our traditional economic system.

The most interesting aspect of price in connection with resource depletion is involved in the question, "What can we afford to pay for a given material?"

There is an absurd side to the fact that a pound of valuable, durable re-usable material (such as copper, lead, or zinc) costs less today than a pound of a common, single-use, short-lived, easily destructible material, such as cotton.

If the consumer can pay much more than the present price in relationship to other commodity prices, as in the case of lead, for example, broad new vistas are opened up in the way of exploratory activity, rejuvenation of old producing areas, opening of remote or low-grade deposits, increased recovery in extraction, and scrap return. Also, if a higher price is needed to produce substantial quantities of lead, some users will drop out of the market. Other dense materials can be used for weighting down fish nets or sailboat keels, less lead can be used in paints, and substitutions can be made in the construction, chemical, and cable-covering fields. Thus, a greater proportion of the present supply of lead will be available for storage batteries and similar dependent users. As for these users, startling as it may seem, it is probable that they could pay 10 times as much for lead and not be seriously handicapped.

The prices we can afford to pay for so-called essential materials finally get back to the human energy we can afford to devote to their acquisition. It seems ridiculous to say that people who enjoy five-day work weeks, in an industrial system that has but few back-breaking jobs, cannot pay 10 times the present relative price for the lead they need. Probably what they need is but a fraction of what they use, and what they use represents less than a thousandth of their earnings.



Had they to pay 10 times as much for their needs, these would probably still require an imperceptible amount of the time now devoted to profitless amusement or the expenditures now made for superfluities. Until and unless we are back to long work weeks and arduous tasks, there seems to be little reason to become excited over the consequences of depletion.

The reader may well pose the question: "If you are so little concerned over depletion, why are you striving to help the United States build up stockpiles and safeguard its future access to raw materials?" The point is that it takes a certain amount of time for industry to adapt itself to new conditions, and these measures are designed to cushion us against being caught unprepared over the short term or in an emergency. Moreover, possession of a resource which the other fellow lacks is likely to afford a competitive or combative advantage to those who "have" over those who "have-not." The problem diminishes if all are equally well off or poor, or are given sufficient time to work out alternatives.

If we can refrain from destroying civilization, or making the world a Communist prison, the future I foresee is one of continued abundance and variety of materials, of slow, almost imperceptible changes toward using materials backed up by abundant reserves, of higher per capita consumption, and greater and greater involvement of complicated technology. We shall require, and be able to afford, more highly educated technical men. We shall receive a greater and greater inheritance of knowledge, comfort, and leisure from preceding generations, and have more of what is commonly called better living. It may be hoped that we shall use these benefits as stepping stones to enlightened, fruitful, satisfying lives, to moral and social progress, and not become narrow or soft-minded slaves to the machines, technologies, ease, and gadgets with which we shall be surrounded.

THE INSTITUTE GAZETTE

(*Continued from page 166*)

Winter Sports Week End

ELEVEN winter sports teams swung into action on December 2 as part of the third annual M.I.T. week-end sports carnival, popularly known as Tech's-a-Poppin. The location of the events alternated between the cities of Boston and Cambridge but the enthusiasm of the participants and guests was not diminished by the time consumed in traveling.

The gay week end of dances and fraternity house parties featured the initial contests of the basketball and hockey teams. Technology's varsity basketball team began activities on the evening of December 2 when it opposed the Boston University quintet at the Cambridge Armory, losing by a score of 57 to 37; a freshman preliminary ended with a score of 74 to 40 in favor of Boston University.

(*Concluded on page 172*)

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THE INSTITUTE GAZETTE

(Continued from page 171)

In the afternoon on December 3, the varsity and freshman swimming meet with Brown took place. Brown's varsity team won the meet, 40 to 35, with the freshmen ending in a 37 to 37 tie. A rifle match with Harvard resulted in a 1,389- to 1,310-point victory for Technology's varsity team, and a 872 to 842 score in favor of M.I.T. freshmen. Other afternoon events included: a varsity squash match with Dartmouth, with an 8 to 3 defeat for M.I.T.; a wrestling match with Tufts, with a 22 to 13 win for the Institute's varsity team; and a demonstration by Technology swordsmen. The week end concluded with a Harvard-won hockey game.

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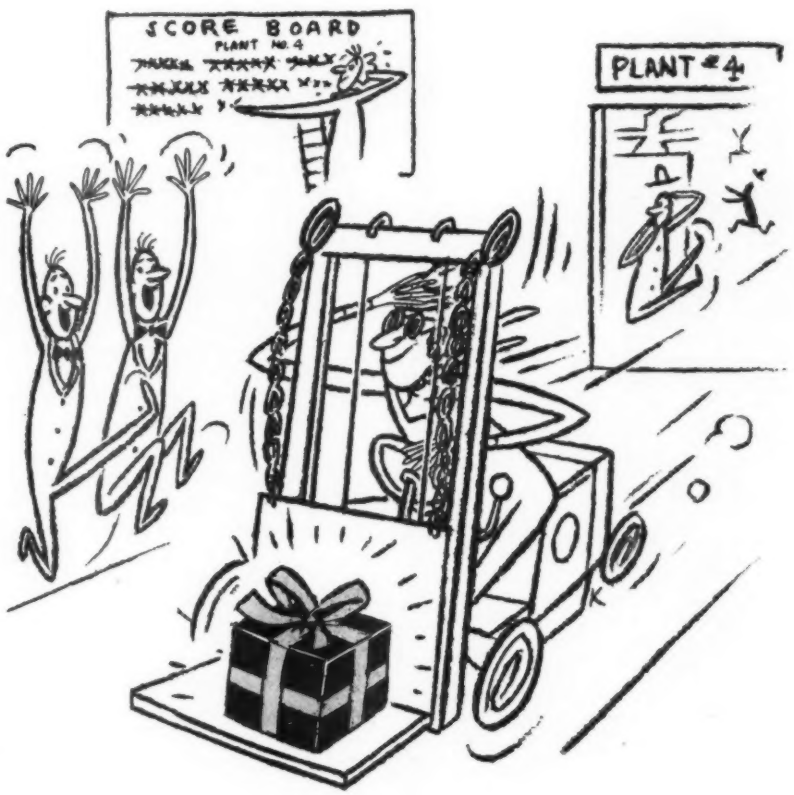

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TWENTIETH CENTURY MID-POINT

(*Continued from page 157*)

America. The first half of the Twentieth Century has seen a remarkable evolution of transportation methods: tanks and tractors, airplanes, Zeppelins, helicopters, submarines, and rockets have crawled, flown, floated, buzzed, swam, or flashed across its stage. But as a sociological force the automobile has no peer. In 1900 the train was virtually the only rapid means of long-distance passenger travel. Passenger miles per capita in this country amounted to about 210 annually from this source, though a significant but unknown amount of traveling was still done on or behind a horse. In 1950, it takes almost as much money to stable a riding horse in a large city as it does to rent a small apartment. American passengers now travel, by steam or Diesel railroads, electric railways, busses, commercial air lines, and private automobiles, about 651,424,000,000 miles per year to establish a per capita travel account of 4,650 miles (in 1945). Of this 1945 total, the automobile accounted for almost exactly two thirds, although private driving was still restricted by wartime exigencies. Although still far behind other forms of travel in number of passenger-miles, travel on domestic commercial air lines multiplied about fiftyfold between 1926 and 1945.

Perhaps the most significant over-all measure of progress that can be found is in education, although as far as quality goes there is hardly a more difficult subject to evaluate. Be that as it may, there has been a great increase in the number of college students, although between 1900 and 1940 the percentage of the total population in school did not greatly alter. (In this connection it is interesting to speculate whether the increase in the span of life has not been one of the factors that has encouraged and justified longer periods of education for our young men and women.) In any case, the enrollment in institutions of higher learning grew from 237,590 in 1900 to 2,338,000 in 1947, almost a tenfold increase for a population that increased by 97 per cent during the same period. As for technical education, the number of engineers in this country in 1890 was 27,000. Today it is over 350,000, to which total M.I.T. has contributed about 40,000 Alumni. In the 1900's the colleges were graduating a few thousand engineers annually. Current postwar graduating classes are in the neighborhood of 30,000 to 40,00 per year, and a steady flow of perhaps 20,000 per year is expected when enrollment stabilizes.

In the field of technical education, it is interesting to recall the growth of M.I.T. during the last five decades. In 1900, there were 1,178 students and an active teaching staff of 172, representing an average of 6.9 students per instructor. In 1949, the student body had increased to 5,433, and the teaching staff to 747, with an average of 7.2 students per staff member. Thus, it is clear that the extent of individual attention which the M.I.T. student received did not suffer in the period in which there was more than a fourfold increase in the student body. On the financial side, Institute operations were $356,000 in 1900, as against $7,000,000 in 1949. Tuition fees during the

(*Continued on page 176*)

"These specifications added up to just one career..."

I WENT from the University of Tennessee directly into the Army. And after the war ended, a lot of serious thinking convinced me that the life work I wanted to follow would have to offer three things:

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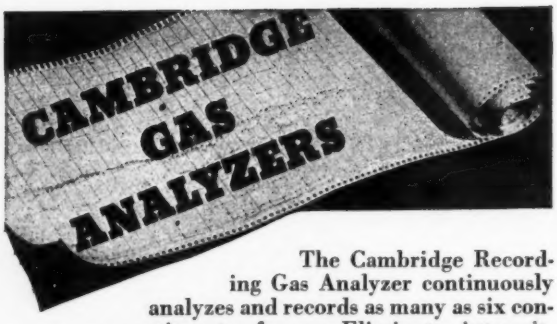

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TWENTIETH CENTURY MID-POINT

(*Continued from page 174*)

same period increased from $200 to $700 (and now stand at $800) per year, but in no year in the Institute's history has tuition covered the average operating expense per student, which figure stood at $301 in 1900 and almost $1,300 in 1949.

In all of the above there has been little direct mention of the sciences, the source from which most of these trends and accomplishments have been derived, and which is now determining the shape of our material well-being for the next 50 years and more. Only the future will be able to judge the most significant findings of the last 50 years of science. It may very well be the discovery of the gene, or the rise of the large digital computers, or some far more obscure theory or happening. But there is no escaping the fact that, in the public mind, the dominating science today is nuclear physics. Chemistry might have held that honor prior to World War I, and astronomy still earlier. However, the concrete and blasting evidence of the atomic bomb, that the unbelievable theories and incredible findings of the atomic physicists were true, has given that field the funds and stimulus to undertake the most gigantic building program that science has ever seen. Physics, long accustomed to working with the most massive equipment of any science except astronomy, is now its own expanding universe. To a population that has just dimly begun to comprehend what a cyclotron is and does, comes the news that physicists are building, or have completed, among other similar items, a 300,000,000 electron-volt betatron, a 300,000,000 electron-volt synchrotron, and a 1,400,000,000 electron-volt bevatron. All are "atom smashers," or more specifically, means for accelerating various ultimate particles of matter to very high speeds so that they may become tools for exploring the nuclei of atoms and for creating, destroying, and manipulating their components. (Many of these devices owe their extraordinary accelerating abilities to the use of huge accurately timed pulses of high-frequency energy, a technique that was developed by the wartime need for long-range radars.

One could go on at length about Twentieth-Century inventions in weapons, poison gases, extraordinary sensing devices, such as radar, sonar, and infrared detectors, proximity fuses, jet and rocket propulsion, and so on. Along with their vast implications for death and evil are a few other facts selected at random. Radar equipment, whose genesis helped in creating our present particle accelerators — which in turn may lead to bigger atom bombs or an inexhaustible source of power for the good of mankind — is also being used on merchant ships and tugboats to hurry the flow of commerce, and several are pointed at the heavens, studying the real music of the spheres and collecting new data on meteors. Radioactive isotopes from the reactors of the Atomic Energy Commission are being shipped in such large lots into so many different industries and laboratories that the technical, and even the news, press is beginning to bristle with articles on their use and handling. In at least one important field, that of biochemistry, these easily traceable elements have been called the

most useful tool available to the investigators. Another science, meteorology, which even more than biochemistry has good cause to identify itself almost exclusively with the past 50 years, has found the long-range artillery rocket, currently in the shape of the German V-2, a useful instrument in exploring the upper atmosphere — a region about which information has been growing rapidly since the invention of radio. The 1947 Nobel prize for physics, incidentally, was awarded to Sir Edward V. Appleton for his work on the ionized layers lying above the stratosphere, although the possibility of such a layer was recognized by another Englishman, Oliver Heaviside, in 1902.

But to turn from this digression, Hideki Yukawa last year also became a Nobel prize winner, for the prediction, made three years before its confirmation as the result of cosmic-ray studies, that there must exist a particle of matter known as a meson. This incident recalls a nearly parallel affair that began when Rutherford in 1920 predicted the existence of the neutron, a particle that was discovered, also from cosmic-ray investigations in 1932. Is the shortened time scale of the later event significant of a faster pace in nuclear research?

These two brilliant predictions bring to mind a similar achievement of the human intellect that stirred the Nineteenth Century, and caused many to call it the most distinguished scientific triumph of that period. By calculations based on the slight perturbations of the planet Uranus, John Couch Adams deduced, about 1845, that there must exist beyond that orbit another planet. A year later Leverrier independently came to the same conclusion. He sent his findings to a German astronomer, who, within 30 minutes, found the planet Neptune. Yet, for all its brilliance, this accomplishment was overshadowed in fundamental importance by Darwin's statement of the theory of evolution.

For all its brilliance, has Twentieth-Century science yet produced a concept of comparable significance?

Perhaps it already has. In this period have been developed Einstein's theory of relativity, Planck's quantum theory, the conceptions of such men as Bohr, de Broglie, Dirac, and Rabi. With his first differential analyzer, Vannevar Bush, '16, opened the modern era in automatic calculating machines, with the present digital computers and their memory circuits beginning to suggest the possibility of approaching the human mind in complexity and power. Possibly the development of huge research organizations and techniques which are able to bring teams of highly trained specialists together to solve a given problem may be the outstanding achievement of the past half century. Or is it the biological discoveries associated with the name of Thomas Hunt Morgan — the knowledge gathered about the actual mechanism of heredity — that will prove in the end to be the most powerful force yet unleashed on mankind? The last few decades have opened entire new chapters in medicine and in the knowledge of the chemistry of life. The secretions of the various body glands have been studied and applied in startling fashion. Purified, and even synthetic, vitamins have come into general use. Chemical drugs of miraculous powers, the sulfanilamides, have ap-

(*Concluded on page 178*)

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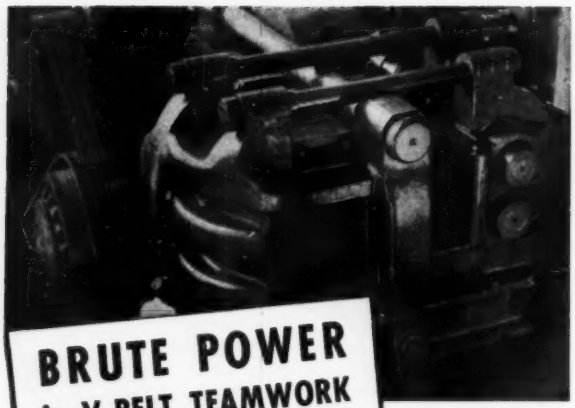

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TWENTIETH CENTURY MID-POINT

(Continued from page 177)

peared, to be followed immediately by still more miraculous antibiotics, such as penicillin and streptomycin. There is no more precious possession, no more valuable resource, than life itself, and in these past five decades nearly a score of years have been added to the span of the average individual's existence.

To every name and achievement that have been listed in these few thousand words, the reader can add his own, and probably better justified, selections. It could not be the aim in such a brief discussion to do more than suggest the richness and variety of this period. Wallace, who with Darwin, was first to glimpse the framework of evolution, called the years between 1800 and 1900 the "wonderful century." The pace, since then, has much more than doubled, and the effects continue to spill over into the realms of economics, sociology, and history. Science is part of that party to which Victor Hugo belonged and which he described in autograph on a wall of the room in which he died, in terms that have been hammered home by two bitter World Wars, as

> . . . a party which does not yet exist:
> the party of revolution, civilization.
> This party will make the twentieth century.
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PFCV-600-20	.090"	#20	7	600	8	.130"	PFRW-600-20
PFCV-600-18	.100"	#18	16	600	12	.145"	PFRW-600-18
PFCV-600-16	.110"	#16	19	600	20	.170"	PFRW-600-16
PFCV-600-14	.120"	#14	19	600	40	.185"	PFRW-600-14
PFCV-600-12	.140"	#12	19	600	55	.200"	PFRW-600-12
PFCV-600-10	.170"	#10	37	600	75	.270"	PFRW-600-10
PFCV-600-8	.220"	# 8	133	600	100	.350"	PFRW-600-8
PFCV-600-6	.260"	# 6	133	600	135	.390"	PFRW-600-6
PFCV-600-4	.320"	# 4	133	600	180	.480"	PFRW-600-4
PFCV-600-2	.390"	# 2	133	600	240	.550"	PFRW-600-2
PFCV-2500-20	.125"	#20	7	2500	5	.180"	PFRW-2500-20
PFCV-13000-14	.220"	#14	41	13000	30	.300"	PFRW-13000-14
PFCV-5000-12	.210"	#12	19	5000	50	.340"	PFRW-5000-12

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TO M.I.T. MEN

In 1917 Walker Memorial Building was opened, a gift from Alumni for the welfare of M.I.T. students. In addition to including offices for student activities and serving as a student social center, this building houses the dining service.

In 1948–49 nearly one million meals were served to staff and students. Morss Hall seats approximately 500 people. Thus, each chair served 2,000 people per year or 5.5 persons per day. We thank the Alumni for making these services possible.

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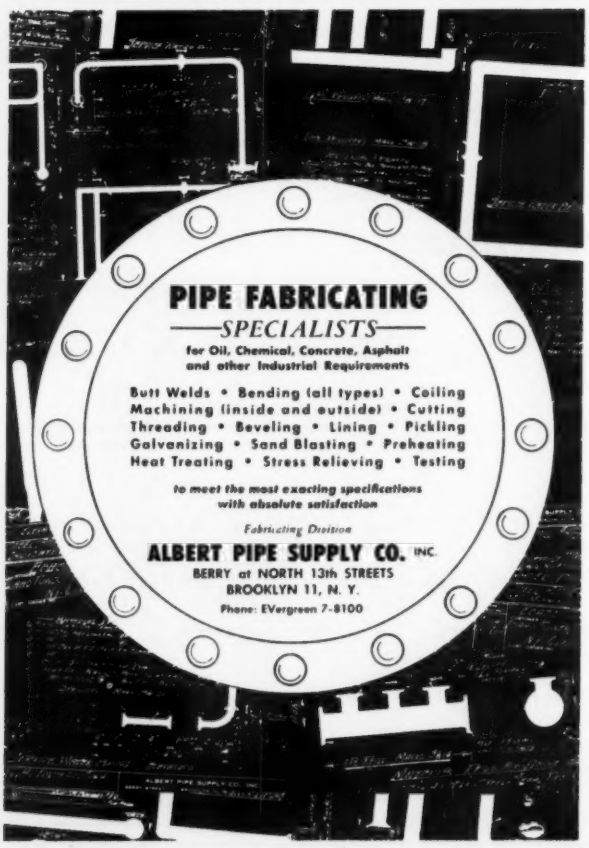
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THE FASTEST TRAINS

(*Continued from page 155*)

averages of over 60 miles an hour between major terminals – by an extra-fare train in each direction on each run daily, except on Sundays and holidays.° Their averages are given below, together with figures illustrating what has taken place since 1930 in the scheduled speeds of the certain famous French-named limiteds, such as the *Golden Arrow* and the *Blue Train:*

			Average miles an hour		
Paris to:	*Miles*	*Train*	*1949*	*1939*	*1930*
Calais	186	*Fléche d'Or*	58.1	58.1	58.1
Brussels	194	*Étoile du Nord*	51.1	63.5	55.2
		L'Oiseau Bleu	47.3	64.0	—
Lyon	318	Nos. 41 and 42†	62.4	—	—
		Calais-Mediterranée Express (Train Bleu)	45.4	52.2	42.7
		Côte d'Azur	44.8	56.8	47.9
Bordeaux	361	Nos. 7 and 8	60.2	—	—
		Sud Express	53.1	64.0	46.8
		Pyrénées Côte d'Argent	53.1	63.5	—
Marseilles	536	Nos. 33 and 34	51.5	—	—
		Calais-Mediterranée Express (Train Bleu)	46.3	53.1	43.8
		Côte d'Azur	46.3	58.3	49.0

† Advertised as *"les plus rapides d'Europe"* in 1949.

Required Customs Stops

The above figures include those for one international service, that between Paris and Brussels, the running times of which are not materially affected by customs delays; in fact, the 1939 and 1930 trains listed ran nonstop between the two capitals. On most other European international runs, however, over-all averages are seriously reduced by required customs stoppages. The southbound *Rome Express*, for example, is now delayed 1.6 hours at Modane, else its Paris–Rome average would be 37.4 instead of 35.1; and *Sud Express* would now average northbound 39.2 instead of 34.9 from Madrid to Paris, were it not for a total of 2.8 hours lost at Irún and Hendaye, In the data which

(*Concluded on page 182*)

° In 1939 there were three French runs at over 70 miles an hour, on all of which the fastest 1949 trains are booked in the 50's, viz.: Paris–Longueau, then 75.7 and now 56.5; Dijon–La Roche, then 74.2 and now 50.3; Nancy–Paris, then 73.0, and now 56.9.

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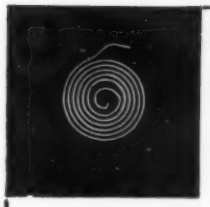

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THE FASTEST TRAINS

(*Continued from page 180*)

follow, no 1949 Paris-Berlin average appears for *Nord Express* since its Berlin section is as yet in postwar operation only as far as Helmstedt:

Paris to:	*Miles*	*Train*	*Average miles an hour* 1949	1939	1930
Berlin	666	*Nord Express*	—	54.1	39.2
Rome (via Modane)	898	*Rome Express*	35.1	43.1	35.5
Madrid	905	*Sud Express*	34.9	38.9	35.3
		Pyrénées Côte d'Argent	28.5	40.3	—
Bucharest	1,617	*Orient Express*	28.9	39.9	35.1
	1,660	*Arlberg Express*	30.2	—	—
Istanbul	1,884	*Simplon-Orient Express*	22.7	34.0	31.7

Frontier Delays

Most affected of all by intervening frontiers is the last named, for the route of the *Simplon-Orient* traverses the soil of seven different political entities—France, Switzerland, Italy, Trieste, Yugoslavia, Bulgaria, and Turkey. Besides the delays of six frontiers, the train remains stationary half a Bulgarian day at Sofia. Thus, its cited current average of 22.7 miles an hour westbound is largely an arithmetical measure of accomplishment against postwar interruptions by this hitherto glamorous train de luxe, favored in an elder day by innumerable rajahs, princes, millionaires, and lovely lady spies to whose exploits aboard allusions may be found in the writings of Agatha Christie, Eric Ambler, and the late E. Phillips Oppenheim, or in the films of portly Alfred Hitchcock.

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NUCLEATION: Such diverse problems as the kinetics of phase transformations, the formation of cracks in solids or of bubbles in liquids, and the formation of reversed domains during demagnetization have been treated in terms of the concepts of nucleation and growth. By nucleation is meant the formation of a new and distinct region separated from its surroundings by a discrete boundary. Nucleation is involved in the formation of a small droplet of water from water vapor, the formation of a small region of body-centered cubic iron within a face-centered cubic matrix, and the formation of a region of ferromagnetic material having one-spin orientation in a matrix in which the orientation of the spins is different.

The problem of nucleation, then, is pertinent to some of the most interesting transformations occurring in nature, and by control of the rate of nucleation the transformations can be controlled. Recently, for example, it has become possible to modify the weather over large geographic regions by simply inducing the nucleation of ice from a cloud of water droplets. Recently also metals have been significantly supercooled by preventing the formation of nuclei over a wide range of temperatures.

American Society for Metals, Cleveland, October 15, 1949

★

A. H. SHARBAUGH,

Research Laboratory

EXPLORING MOLECULES: One of the outgrowths of the intensive research in the radar field during World War II has been the opening of a promising new field: that of exploring the molecule with radio waves . . . With a microwave spectrometer we cause radio waves about ½-inch long to pass down a long hollow pipe which is filled with the gas we wish to study. At the far end we measure the radio power with a crystal detector and show the pattern on a television tube. Every time we tune the microwave source through an absorption line we see a sharp dip in the trace on the oscilloscope or television tube. By tuning over the available frequency range, we find out experimentally all the frequencies where the energy is absorbed as well as how strongly it is absorbed.

One advantage that microwave spectroscopy holds over the kinds of spectroscopy practiced at shorter wavelengths, as in the region of visible light, is the ability of the microwaves to distinguish between absorption lines that are very close together. This quality, known as resolution, is several thousand times better than the best optical instruments . . .

By using a crystal oscillator checked with WMV, the Bureau of Standards station at Washington, D. C., we may generate standard reference markers throughout the frequency range of the spectrograph. By means of these we can measure experimentally our absorption lines to about 1 part in a million. Not quite all this accuracy is retained in the molecular geometry because of uncertainties in Planck's constant and the fact that the molecule may be slightly flexible and disturb our measured interatomic distances. In spite of these limitations, we may calculate from experimental data the distances between atoms to an accuracy of 1/1000 of an angstrom unit or 1/100 of a millionth of an inch!

The fact that these microwave absorption lines are extremely sharp and very stable opens up the avenue to some interesting applications. One of these is the use of the spectroscope as an analytical tool for chemists. The frequency range currently used in microwave spectroscopy is from about ½ cm. to 2 cm. in wavelengths and, even in this relatively small region so far investigated, there is room for 5 million noninterfering rotational absorption lines. In principle, it is believed that a thousand or more different complex organic molecules could be determined from a sample weighing less than 1 ten-millionth of an ounce without harming it in any way and without using up the sample . . .

Although microwave spectroscopy primarily yields information about the structure of the molecule as a whole, it may also be used for studying the rotation of internal groups of atoms within the molecule.

General Electric Science Forum, WGY, September 28, 1949

★

C. G. SUITS,

Vice President and Director of Research

ATOMIC POWER: It is probable that about $200 million will have to be spent in the process of building successive experimental power plants before we will have a proper basis for judging the future economic possibilities of atomic energy. Because of the great array of unanswered technical questions, there can be no assurance at present that the final result will be successful. If a profitable atomic industry ever develops, it is certainly decades in the future. This financial risk is obviously one which cannot be supported by any private capital in the world, so that it is clear from the outset that only the resources of the national government can sustain the required effort. Not only does the great cost of the development make it necessary for the national government to foot the bill, but the fact that fuel for atomic power plants is also the explosive material of atomic bombs makes it necessary for the federal government to control the security and accountability aspects of the project in great detail. All atomic energy work is thus the responsibility of the Atomic Energy Commission and is carried out in laboratories operated by its contractors.

National Academy of Sciences, Rochester, N. Y., October 25, 1949

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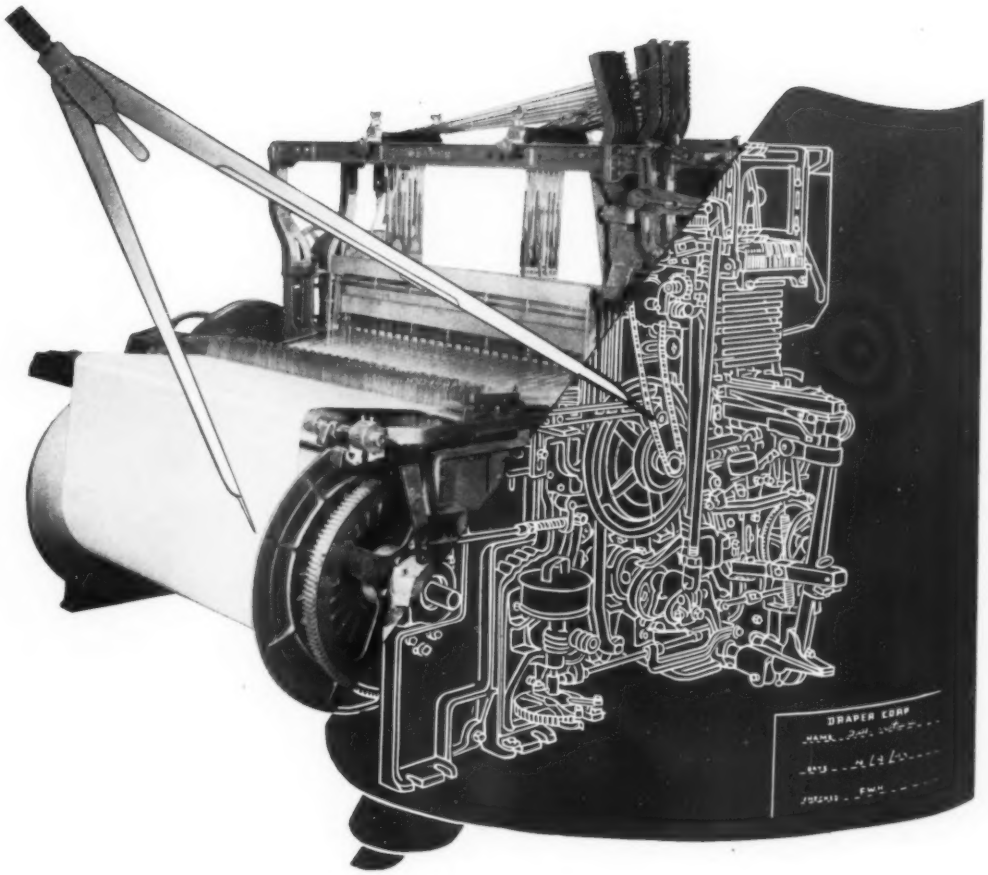

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